NASA CR-143665

EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY

REPORT NO. 3: DESIGN/COST TRADEOFF STUDIES

• Appendix C: EOS Program Requirements Document

(NASA-CR-143665) EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY. REPORT NO. 3: DESIGN/COST TRADEOFF STUDIES. APPENDIX C: EOS PROGRAM REQUIREMENTS DOCUMENT (Grumman Aerospace Corp.) 162 p HC G3/18 N75-15711 Unclas 09248

GRUMMAN

EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY

REPORT NO. 3: DESIGN/COST TRADEOFF STUDIES
• Appendix C: EOS Program Requirements Document

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

Prepared By

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

NAS 5-20520

September 1974

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.

REPORT

NO EOR-74-001 DATE May 31, 1974

E O S REQUIREMENTS DOCUMENT

CODE 26512

PREPARED BY R. Pratt/B. Sidor

TECHNICAL APPROVAL

CHECKED BY

APPROVED BY

DEPARTMENT

APPROVED BY

SECTION

APPROVED BY

REVISIONS

DATE	REV BY	REVISIONS & ADDED PAGES	REMARKS
7/12/74	RLP	See following page	Document re-issued

GAC 324A REV. 3
10-70

NO.	REVISION	DATE
1	Replace i, ii, iii, vi Add 2.6-1, 2.6.1-1, 2, 3, 5, 6, 6; 2.6.2-1, 2.3, 4; 2.6.3-1, 2, 3, 4; 3.18.1-1, 2, 3, 4, 5, 6, 7	6/6/74
2	Delete: 2.4-1; 2.5-1 Replace: i, ii, iii, iv, v, vi, vii, viii, ix, x, xi; 1.0-2; 2.1-1; 2.2-1; 2.3-1; 3.4-1; 3.6-1 Add: xii; 2.1-2, 3, 4; 2.3-2, 3, 4, 5, 6, 7, 8, 9, 10; 3.1-1, 2, 3; 3.2-1; 3.3-1; 3.8-1; 3.9.1-1, 2, 3; 3.9.2-1, 2; 3.9.3-1, 2; 3.10-1, 2, 3, 4, 5, 6, 7; 3.11.1-1, 2; 3.11.2-1; 3.11.3-1; 3.11.4-1, 2, 3, 4, 5, 6, 7, 8, 9; 3.11.5-1, 2; 3.13-1; 3.14-1; 3.15-1; 4.1.1-1; 4.1.7-1; 4.4.4-1	6/14/74
3	Replace v	6/18/74
4	Delete: 3.10-1, 2, 3, 4, 5, 6 & 7; 4.1.5-2 Replace: ii; 3.6-1; 3.18.1-4 & 7; 4.1.5-1 Add: 3.6-6; 3.17-1, 2, 3, 4, 5, 6, 7, &8; 3.16-1 & 2	6/21/74
5	Replace i, iv, v, vi, xi, xii, 1.0-3; 2.1-2; 2.2-1; 4.1.1-1; 4.1.7-1 Add: 2.1-5, xv, 4.1.7-2 Revise: Change page no. vi to vii, vii to viii, viii toix, ix to x, x to xiii, xi to xiv,	6/28/74
6.	Delete: vi Replace: ii, iv, v, 2.2-1 Add: 2.6.1-7, 3.18.2-1, 2, 3, 4, 5, 6, 7 & 8	7/5/74
7.	Document re-issued as option designation revised on all pages Replace: vi, vii, viii, ix, xi, xiv; 2.1-1, 2, 4 & 7; 3.5-1; 3.16-1; 4.1.2-3; 4.1.3-3 Add: 2.1-3; 2.1-5/6,-8,-9; 3.5-3,4; 3.9.4-1,2; 3.11.4-10,11,12; 3.12-1; 3.13-2; 4.1.8-1,-2; 4.2.3-5, 6, 7, 8 & 9	7/12/74

Insert after title page.

CONTENTS

CONTENTS

CONTENTS (CONT)

CONTENTS(CONT)

Introduction

This document serves as the basis for the subsequent EOS System Specification. It consists of requirements obtained from existing documentation and those derived from functional analysis. After EOS trade studies have been completed the requirements identified will be incorporated.

Requirement Page Nomenclature

Requirements follow the hierarchy of Program, Mission, System and Subsystem.

The "Source" column on the attached pages references the location of the requirements contained in existing documentation or those derived by GAC functional analysis

e.g. X/XX.X.X/X   FA   X.XX.X

Source Document   Para. No.   Page No.   Functional Analysis   Block No.

In addition, where applicable, relevant System Trades which constrain the requirement are identified in paratheses.

e.g.

(TS X)

Study Number (refer to Systems Trades list, page vi)

Trade Study designation

The "Option" column identifies the applicability of requirements to each of the GAC EOS options being considered by placing a dot in the appropriate column. An open dot (o) is for interim requirements and a solid dot (●) indicates a verified requirement. Options are contained in the table on page v.

S/C OPTIONS

OPTION		1			2	3		4	5
LAUNCH VEHICLE	BOOSTER ALLOW. S/C SIZE	DELTA 2910 237" LONG X 86" DIAMETER			WT. CONST. TITAN 237" LONG X 86" DIA	TITAN III B 381" LONG X 110" DIAMETER		TITAN III C 683" LONG X 110" DIA.	SHUTTLE 60 FT X 15 FT. DIA
MISSION	Designation	A & A'	Alternate	D	B & B'	C	E	F	
	Inclination	98°	98°	90°	98°	98°	103°	0°	
	Altitude	366 X 366 n. mi.	493 X 493 n. mi.	324 X 324 n. mi.	366 X 366 n. mi.	100 X 366 n. mi.	100 X 915 n. mi.	19300 X 19300 n. mi.	
	Weight to Orbit	2560	2430	2625	3730	5150 lb.	4500 lb	5600 lb	
BASIC SPACECRAFT	Barebones Wt.	1485		1485	1485	1485	1485	1485	
	Orbiter Retrieval	36		36	36	36	36	36	
	Orbiter Resupply	107		107	107	107	107	107	
	2 Yr Service Life	32		32	32	32	32	32	
	Increase Struct. Cap.	—		—	35	60	60	80	
	Contingency	20		20	31	32	32	35	
	Weight	1680 lb		1680 lb	1722 lb	1752 lb	1752 lb	1776 lb	
SPACECRAFT MISSION PECULIAR	Elect. Power (Battery)	—		64	—	64	32	—	
	Solar Array	—		84	—	84	23	—	
	Attitude Control	—		—	—	145	145	145	
	Comm. & Data Handling	4		—	4	4	—	—	
	Orbit Adjust/Transfer	27		27	40	351	1589	27	
	Contingency	—		23	—	57	52	54	
	Sub-Total Weight	31 lb		198 lb	44 lb	705 lb	1841 lb	[illegible] lb	
INSTRUMENTS	S Band [illegible]	160			400	800 (2)			
	TM	400			400	400			
	[illegible]								
	DCS	53			53	53			
	SAR					500			
	Altimeter								
	Scatterometer			705					
	IR Scanner								
	Coherent Radar Experiment								
	Very High Resolution Radiometer								
	Operational Vertical Sounder								
	Scanning Multichannel Microwave Radiometer						770		
	Microwave Radiometer/Scatterometer								
	Cloud Physics Radiometer								
	Space Environment Monitor								
	DCS								
	Large Aperature Survey Telescope							2300	
	Sub-Total Weight	613 lb		706 lb	853 lb	1753 lb	770 lb	2300 lb	
INSTRUMENT MISSION PECULIAR	Structure	90		70	120	225	80	230	
	Resupply Latches	32		53	32	53	42	21	
	Thermal	11		9 (TDRS)	22	40	11 (TDRS)	160 (Direct)	
	WB Tape Recorder -EPTS	155 (2)		—			—	—	
	-TM			—	400	400	—	—	
	WB Comm - Ant.	40		110	40	60	80	40	
	- [illegible]	14			22	38		14	
	[illegible]	34			34	48		34	
	Contingency	24		25	30	56	24	52	
	Sub-Total	400 lb		267 lb	700 lb	920 lb	237 lb	[illegible] lb	
Avail. For Mission Peculiar		980		1145	2008	3398	2748	3824	
Mission Peculiar (from above)		1044 lb		1171 lb	1597 lb	3378 lb	2848 lb	3105 lb	
[illegible] Saving Options		112		166	—	—	126	—	
[illegible]		48 lb		140 lb	411 lb	20 lb	26 lb	719 lb	

X

Revision 6

Date

ORIGINAL PAGE IS OF POOR QUALITY

SYSTEM TRADE STUDIES

1. Orbital Altitude Selection
2. Launch Vehicle Selections
3. Shuttle Compatibility
4. Instrument Approach
5. Data Operations
6. Attitude Control System/Central Processing Facility
7. Spacecraft Autonomy/Hardware vs. Software
8. Electronic Technology
9. International Data Acquisition
10. User/Science and Orbit Time of Day Studies
11. Utilization of Control Center Personnel
12. Coupled vs. Uncoupled Pneumatics
13. Wide Band Data Format
14. Modularity Level
15. Design Growth Economic Study
16. Single Satellite vs. Multiple Satellites
17. Management Approach
18. Test Philosophy
19. Reliability and Quality Assurance

TABLE OF WBS VS. REQUIREMENTS

WBS (Rev. D)		REQUIREMENTS
1.0	EOS Program	1.0
1.1	Program Management NASA	Not Applicable
1.2	Data Management System	3.12
1.2.1	Project Management	Not Applicable
1.2.2	Systems Engineering and Integration	Not applicable
1.2.3	Documentation	Not Applicable
1.2.4	Central Data Processing Equipment	4.2
1.2.4.1	Pre-Processing	4.2
1.2.4.2	Processing Equipment	4.2
1.2.4.3	Products Production	4.2
1.2.4.4	Archives	4.2
1.2.4.5	Information Management System Equipment	4.2
1.2.4.6	Interfacing Systems Equipment	4.2
1.2.4.7	Facilities	4.2
1.2.5	Low Cost Ground Station Equipment	4.2.4
1.2.6	Data Acquisition	4.2
1.2.7	Software	4.2
1.2.8	Spare Parts	4.2
1.2.9	Expendables	4.2
1.2.10	Operation and Maintenance	4.2
1.3	Instruments	3.5
1.3.1	LRM Instrument	3.5
1.3.1.1	Thematic Mapper (TM)	3.5.1
1.3.1.2	High Resolution Pointable Imager (HRPI)	3.5.2
1.3.1.3	Data Collection System (DCS)	3.6
1.3.2	Follow-On Instruments	3.5
1.3.2.1	Passive Multichannel Microwave Radiometer (PMMR)	3.5
1.3.2.2	Synthetic Aperature Radar (SAR)	3.5.3
1.3.2.3	Synchronous Earth Observatory	3.5
1.3.2.4	Sea Satellite (SEASAT)	3.5
1.3.2.5	Five Band Multi-Spectral Scanner (MSS)	3.5

WBS VS. REQUIREMENTS

WBS		REQUIREMENTS	
1.3.2.6	Solar Maximum Mission (SMM)	3.5	
1.4	Flight Operations and Services	3.13	
1.4.1	Ground Command Control and Tracking	3.14	
1.4.1.1	Telemetry Transmission	3.14	
1.4.1.2	Computer Program	3.13	
1.4.1.3	Mission Planning	3.13	
1.4.1.4	Project Control Center	3.14	
1.4.1.5	Data Analysis	3.14	
1.4.1.6	Network Modifications	3.14	
1.4.1.7	GFSC Operations	3.14	
1.4.2	Retrieval Resupply & Operations Support	3.8	2
1.5	Launch System	3.7	
1.5.1	Launch Vehicle	3.7	
1.5.2	Shroud & Adapter	3.7	
1.5.3	Operations Support & Servicing	3.7	
1.5.4	Payload Interfaces	3.10	
1.6	Shuttle Resupply Project	3.8	
1.6.1	Manipulator System	3.8	2
1.6.2	Storage System	3.8	
1.7	Spacecraft Project	3.4	
1.7.1	Project Management	N/A	
1.7.1.1	Project Control	N/A	
1.7.1.2	Configuration Management	N/A	
1.7.1.3	Data Management	N/A	
1.7.1.4	Cost Performance Management	N/A	
1.7.2	Systems Engineering & Integration	N/A	
1.7.2.1	Systems Analysis	N/A	
1.7.2.2	System Integration	N/A	
1.7.2.3	Test Requirements & Definition	3.18	
1.7.2.4	Control Center Definition	3.14	
1.7.2.5	Reliability	3.2	2
1.7.2.6	Safety	3.1	

ORIGINAL PAGE IS
OF POOR QUALITY

WBS VS. REQUIREMENTS

	WBS	REQUIREMENTS	
1.7.2.7	Quality Assurance	N/A	
1.7.2.8	Maintainability	3.3	
1.7.3	Spacecraft	4.1	
1.7.3.1	Basic Comm. & Data Handling Model	4.1.2	
1.7.3.2	Basic EPS Module	4.1.3	
1.7.3.3	Basic ACS Module	4.1.4	
1.7.3.4	Basic On-Board Software	4.1.2	2
1.7.3.5	Structure/Thermal	4.1.5 & 6	
1.7.3.6	Inst. Mission Peculiar & Structure	4.1.5	
1.7.3.7	Mission Peculiar EPS	4.1.3	
1.7.3.8	Mission Peculiar ACS	4.1.4	
1.7.3.9	Mission Peculiar Orbit Adjust	4.1.1	
1.7.3.10	Mission Peculiar Pneumatics	4.1.7	
1.7.3.11	Mission Peculiar Orbit Transfer	4.1.1	
1.7.3.12	Mission Peculiar On-Board Software	4.1.2	2
1.7.3.13	Shuttle Flight Support System	3.11	
1.7.3.14	Integration & Test	N/A	
1.7.3.15	Mission Peculiar Comm/Data Handling	4.1.2	
1.7.4	Spacecraft GSE	4.3	2
1.7.4.1	Electrical GSE	4.3	
1.7.4.2	Mechanical GSE	4.3	
1.7.4.3	Fluid GSE	4.3	
1.7.5	Logistics Support	4.4	
1.7.5.1	Spares	4.4.1	
1.7.5.2	Training	4.4.2	
1.7.5.3	Publications	4.4.3	
1.7.5.4	Transportation & Handling	4.4.4	
1.7.5.5	Inventory Control & Warehousing	4.4.5	
1.7.6	Facilities	4.5	

WBS VS. REQUIREMENTS

	WBS	REQUIREMENTS
1.7.6.1	Manufacturing/Engineering	4.5
1.7.6.2	Launch	4.5
1.7.6.3	Project Control Center	4.5
1.7.6.4	STDN	4.5
1.7.6.5	Recovery & Refurbishment	4.5
1.7.6.6	Site Activation	4.5
1.7.7	Vehicle Level Test	3.18
1.7.7.1	Dev./Qual. Test Operations	3.18
1.7.7.2	Dev./Qual. Test Hardware	3.18
1.7.7.3	Orbit Test Hardware	3.18
1.7.7.4	Orbital Test Operations	3.18
1.7.8	Spacecraft Refurbishment	4.6

2

LIST OF ACRONYMS

ACM	Attitude Control Module
ACS	Attitude Control System
AGE	Aerospace Ground Equipment
AOP	Advanced On-Board Processor
ARC	Absolute Radiometric Calibration
ATS-F	Applied Technology Satellite F
BER	Bit Error Rate
B/L	Baseline
BPA	Bus Protection Assembly
BST	Boresighted Star Tracker
BPSK	Biphase Shift Keying
CC	Control Center
CCP	Ground Control Points
C&DH	Communications & Data Handling
CDP	Central Data Processing
CIPS	Conical Image Plan Scanner
CMD	Command
CMD/TLM	Command/Telemetry
CDPF	Central Data Processing Facility
CSC	Computer Sciences Corporation
DMS	Data Management System
DOD	Department of Defense
DOMSAT	Domestic Satellite
DPS	Data Processing System
EBR	Electron Beam Recorders
ELMS	Earth Limb Measurements Satellite
EMC	Electro Magnetic Compatibility
EOS	Earth Observatory Satellite
ERTS	Earth Resources Technoloty Satellite
FHT	Fixed Head Tracker
FMEA	Failure Mode Effects Analysis
FOM	Figure of Merit
FSK	Frequency Shift Keying
FSS	Flight Support System
GAC	Grumman Aerospace Corporation
GFE	Government Furnished Equipment
GLS	Ground Logistics System
GPS	Ground Processing System
GSE	Ground Support Equipment
GSFC	Goddart Space Flight Center
HPRI	High Resolution Pointable Imager
ICD	Interface Control Document
IMPATT	Impact-Avalanche and Transit Time
IMS	Information Management SYSTEM
LBR	Laser Beam Recorder
LCGS	Low Cost Ground System
LIPS	Linear Image Plane Scanner
LOPS	Linear Object Plane Scanner
LRM	Land Resource Management
LSA	Limited Space Charge Accumulation
L/V	Launch Vehicle
MBPS	Megabits Per Second
MEM	Module Exchange Mechanism
MEM	Multiplexer/Encoder Module
MLI	Multi Layer Insulation
MOMS	Multi-Megabit-Operation Multiplexer System
MSS	Multi Spectral Scanner
MUS	Magnetic Unloading System
MUX	Multiplexer
NASCOM	NASA Communications
NEFD	Noise Equivalent Flux Density
NM	Nautical Mile
NRZL	Non Return to Zero Level
NTTF	NASA Test & Training Facility
NUS	No Upper Stage
OAO/LST	Orbiting Astronomical Observatory/Large Space Telescope
OAS	Orbit Adjust Subsystem
OBC	On-Board Computer
OBDC	On-Board Data Compaction
OBP	On-Board Processor
OPS	Operations
OTS	Orbit Transfer Subsystem
OWS	Orbital Workshop (Skylab)
PCM	Pulse Code Modulation
PCU	Power Control Unit
PDSS	Precision Digital Sun Sensor
PDU	Power Distribution
PGST	Precision Gimballed Star Tracker
P/L	Payload
PMMR	Passive Multichannel Microwave Radiometer
PRN	Pseudo Random Noise
PRU	Power Regulation Unit

LIST OF ACRONYMS (Cont'd)

PSK	Phase Shift Keying
PSM	Power Supply Module
QPSK	Quadrophase Shift Keying
REL	Reliability
RF	Radio Frequency
RGA	Rate Gyro Assembly
RMS	Remote Munipulator System
ROM	Read Only Memory
R&QA	Reliability & Quality Assurance
RS	Resupply System
RTC	Real Time Commands
RTS	Remote Tracking Site
SAMS	Shuttle Attached Manipulator System
SAR	Synthetic Apperture Radar
S/C	Spacecraft
SCO	Sub-Carrier Oscellation
SEASAT	Sea Satellite
SEOS	Synchronous "EOS"

SM	Subsystem Module
SMM	Solar Maximum Mission
SMS	Synchronous Metrological Satellite
SNR	Signal-Noise Ratio
SOW	Statement of Work
SRM	Solid Rocket Motor
SSR	Scanning Spectral Radiometer
STAB	Space Transporation & Budget
STDN	Space Tracking Data Network
S/V	Space Vehicle
TDRS	Tracking & Data Relay Satellite
TBD	To Be Determined
TEA	Transferred Electron Amplifier
TEO	Transferred Electron Oscillator
T IIID	Titan IIID
T & IS	Test & Integration Station
TM	Thematic Mapper
TRAPATT	Tapped-Plasma-Avalanche Triggered Transit
TWTA	Traveling Wave Tube Amplifier
WBS	Work Breakdown Structure
WBVTR	Wide Band Video Tape Recorder

DEFINITIONS

S/V Spacecraft and Launch Vehicle

Basic S/C-Standard Modules

S/C Payload-Instruments

β - Beta angle is the minimum angle formed by the earth sun line and the orbit plane

SOURCE DOCUMENTATION

A. Request for Proposal No. 5-66203-202, "Earth Observatory Satellite System Definition Study," dated 17 January 1974.

B. GAC Memo NSS-TR-74-005, "EOS System Definition Study General & Splinter Meetings at GSFC 4/17/74," dated 19 April 1974.

C. GAC Memo NSS-TR-74-004, "EOS Kick-off Meeting at GSFC 4/15/74," dated 16 April 1974.

D. Arthur D. Little, Inc. Report, C-75567, "Thermal Design of the Earth Observatory Satellite - An Interim Report," dated September 1973 (Ref. 1.5.15).

E. GSFC Report EOS-410-05, "Demonstration Model Spacecraft Description," dated September 1973 (Ref. 1.5.2)

F. GSFC Report EOS-410-04, "Performance Specification for Spacecraft Subsystems," dated 14 September 1973 (Ref. 1.5.1).

G. GSFC Report EOS-410-07, "The Earth Observatory Satellite (EOS) - A System Concept," dated 4 September 1973 (Ref. 1.6.1).

H. ORI Technical Report 769, "Study of Data Collection Platform Concepts- Final Report- Data Collection System User Requirements," dated April 1973 (Ref. 1.2.7).

I. GAC Memo EOM-74-033, "Earth Observatory Satellite, System Definition Study Guidelines," dated 14 May 1974.

J. GAC Memo SDM-73-085, "EOS Orbit Analysis," dated 14 May 1974.

K. GSFC Report, "Seasat-A Phase A Study Report," dated Aug. 1973 (Ref. II.B.1).

L. MSFC Report, "Payload Descriptions-Vol.I-Automated Payloads", dated October 1973.

M. GSFC Report X-703-74-42, "Solar Maximum Mission (SMM) Conceptual Study Report," dated January 1974 (Ref. II.A.1)

N. GSFC Table, "SEO S Instrument." (Ref. II.D.3)

O. GSFC Table, "Seasat Instrument" (Ref. II.B.4)

P. IEEE, "Earth and Ocean Physics Applications Program," 1974 IEEE International Convention (Ref. II.B.3)

Q. GSFC Table, "SMM Instrument" (Ref. II.A.2).

R. GAC Memo EOM-74-059, "EOS Reference System Definition, Revision A dated 29 May 1974.

S. GAC Memo EOM-74-060, "Qualification and Acceptance Dynamic Test Requirements for Components," Rev A, 31 May 1974. 2

T. MDAC Report DAC-6 1687, "Delta Spacecraft Design Restraints," Revised November 1973 (Ref. 2.4.1)

U. MMC Report M-70-7 (Rev. 1), "Performance and Characteristics Handbook, Titan III Vehicle Family," revised January 1973.

V. GAC Memo EOM 74-074, "S/C GSE Requirements," dated 6/3/74.

W. GAC Memo 74-064," EOS GSE Requirements," dated 5/29/74.

X. Unpublished GAC Memo, "Tentative Sensor Interface - Hughes TM" 2

Y. GSFC Memo EOS-410-8, "High Resolution Pointable Imager Specification for Baseline EOS," dated 9/24/73 (Ref 1.1.10).

Z. Westinghouse Report, "Final Report, Spaceborne Synthetic Aperture Radar Pilot Study," dated 4/11/74

AA GAC Memo EOM 74-044 EOS System Study Configuration rev. A dated 5/29/74.

AB MMC Report LR-73-1, "Mission Planning Guide-Titan IIIC," dated Feb. 1974.

AC NASA/JSC Report JSC 07700, Volume XIV, "Space Shuttle System Payload Accommodations," Rev. B dated 12/21/73 (Ref. 2.4.3 a).

AD GSFC Internal Memo to W.A. White from E. Painter, Data Collection System for EOS-A, dated May 21/74

AE Martin Marietta Document, Titan Candidate Launch Vehicles for EOS Missions at WTR, dated 10/73 5

AF GAC Memo, EOM 74-085 Impulse Requirements for Pneumatics & Orbit Adjust Modules, dated 6/7/74

AG GAC Memo, EOM 74-127, Spacecraft Dynamic Test Requirements, dated 6/28/74

AH GAC Memo, EOM 74-113 CDP-Thruput Considerations and Data Output Formats, dated 6/24/74

AI GSFC Document, Payloads Description. dated 10/73

AJ GAC Memo EOM 74-090, Meeting With J. Purcell at GAC 6/7/74 7

AK Operations Research, Inc. Report, Passive Multichannel Microwave Radiometer (PMMR) Feasibility Study, dated 6/15/73

AL GFSC Report, Synchronous Earth Observation Satellite (Ref. II D2)

AM GAC Memo, EOM 74-114, Wide Band Data Handling & On board Data Compaction Subsystem Specification dated 6/24/74.

REQUIREMENT	SOURCE	1	2	3	4	5	A	B	C	D	E	F	
1.0 PROGRAM													
1.0.1 The Earth Observatory Satellite (EOS) Program shall provide a flexible, low cost spacecraft for use with existing launch vehicles that will enable even lower costs when used with the Space Shuttle.	A/amend. 1/1	●	●	●	●	●					●	●	●
1.0.2 The baseline system shall consist of:													
Instruments-Thematic Mapper & High Resolution Pointable Imager	A/2.1.1/2-1 A/1.5.1&2/1-6&7	●	●	●	●	●							
Shuttle Compatible Design	A/1.5.3/1-7	●	●	●	●						●	●	●
Resupply Capability	A/1.5.4/1-7	●	●		●						OK		
Data Collection System	A/2.1.1/2-1	●	●	●	●	●					●	●	●
Modular Subsystem Design	A/2.2.3/2-8	●	●	●	●						OK		
Transition Ring Concept for Booster Compatibility	A/2.2.3/2-8	●		●									
Launch vehicles are Delta 2910, Titan III D/NUS, and Shuttle	A/1.3.6/1-5	●	●	●	●	●					●	●	●
1.0.3 The system contractor will assume responsibility for the instruments	A/1.1/1-1	●	●	●	●	●							
1.0.4 Provide flexibility in S/C design to accommodate follow-on mission instruments.	A/1.2/1-2	●	●	●	●	●							
1.0.5 Follow on instruments are the Synthetic Aperture Radar (SAR) and the Passive Multichannel Microwave Radiometer (PMMR)	A/2.3/2-9	●	●	●	●	●							
1.0.6 Demonstrate the spacecraft is capable of accommodating the instruments for the following missions: SEASAT, solar maximum mission, SEOS, and 5-band MSS.	A/amend 1/1										●	●	●
1.0.7 Provide spacecraft that demonstrate the operational requirements of the Department of Interior	GAC	●	●	●									
1.0.8													
1.0.9													

Revision 7 Date 7-12-7-

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
1.0.10	Maintain EOS capability in the decade of the '80's using retrieval, relaunch and in-orbit service capabilities of the Space Shuttle System.	A/1.4.4/ 1-6	●	●	●	●	
1.0.11	The EOS will be launched from WTR except the Shuttle demonstration flight & SEOS which will be launched from ETR	I/-/1	●	●	●	●	●

5

MISSION REQUIREMENTS

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
2.1 MISSION MODEL 2.1.1 Land Resources Management (LRM)						
2.1.1.1 Mission Objectives o Develop sensor and other spacecraft systems to acquire spectral measurements and images suitable for generating thematic maps of the earth's surface. o Operate these systems to generate a data base from which land use information such as crop or timber acreages or volumes, courses and amounts of actual or potential water run-off and the nature and extent of stresses on the environment will be extracted. o Demonstrate the application of this extracted information to the management of resources such as food and water, the assessment and prediction of hazards such as floods, and the planning and regulation of land use such as strip mining and urbanization.	G/1.0/1-1	●	●	●	●	●
2.1.1.2 Mission Description The basic requirement of the LRM instruments is repeating earth coverage under nearly constant observation conditions. This requires a circular sun synchronous orbit with an integral number of orbits and days per repeat ground trace pattern. Preliminary analysis indicates that a solar orbit of 98° inclination with an orbital altitude of 366 nm. meets all requirements.	J/-/1 [illegible]- 1&18)	○	○	○	○	○
2.1.1.3 Payload Instruments The following instruments in various combinations are planned for for the LRM missions: Thermatic Mapper, High Resolution Pointable Imager, Data Collection System, 5 Band Multi Spectral Scanner.	AJ/-/-						7

REQUIREMENT	SOURCE	1	2	3	4	5	A	B	C	D	E	F
2.1.2 Seasat Mission												
2.1.2.1 SEASAT A												
Mission Objectives The SEASAT-A mission is designed for development and demonstration of space techniques for forecasting and monitoring sea state, currents, circulation, pileup, storm surges, tsunamis, air/sea interactions, surface winds, and ice formations.	K/1.1/1-1											
Mission Description A nominal orbit altitude of 391 n.mi. (725 km) is high enough to avoid orbit uncertainties due to drag and low enough to obtain good radar performance with acceptable power consumption. An 82° inclination provides good earth coverage, non-sunsynchronous, to high latitudes.	K/1.1/1-1											
2.1.2.2 SEASAT B												
Mission Objectives Provide data for short-wavelength gravity field determination for earthquake and geoid mapping. Provide data in support of ocean studies such as large amplitude ocean features, currents, circulation systems, temporal variations, ocean geoid and surface conditions. These conditions include sea state/surface wave height, wind fields, shelf tides, ocean tides, barometric pressure, storm surges and tsunamis	L/OPO7A/A-2 (TS 2.17)	●									●	
Mission Description Nominal circular orbital altitude of 324 n mi (600 km) at an inclination of 90°.	L/OPO7A/A-1	●									●	
Payload Instruments See table 2.1.2-1.	AI/-/6-88											

7

AUTOMATED PAYLOAD

MISSION EQUIPMENT

Data Sheet No. A-3

Payload No. OP07A

Date 16 July 1973 Rev. A

Payload Name SEASAT-B

EQUIPMENT			UNIT SIZE, m (ft)			7. UNIT VOLUME, m³ (ft³)	8. UNIT WEIGHT, kg (lb)	UNIT POWER			UNIT DATA OUTPUT		FIELD OF VIEW, radians (degrees)		ENVIRONMENT CONSTRAINTS		18. REMARKS
1. Ref. No.	2. Name	3. Qty	4. Width or Dia.	5. Height	6. Length			Level, watts: 9. Average	10. Δ Peak	11. Peak Duration, sec.	12. Form: A, D, film	13. Rate, Hz, b/s, frames	14. Instantaneous	15. Total	16. Contam. Sensitivity	17. Temp, °K	
OP 039	Altimeter (K-band pulsed altimeter)	1	.2 (0.66)	0.2 (.66)	0.5 (1.64)	0.02 (0.71)	45 (100)	100	-	-	D	1E+04	0.175 (10)	0.175 (10) Nadir	Class 100,000	290 ± 20	Measure ocean height to 0.1m precision (Pulse compression techniques)
OP 040	Scatterometer (K-band, CW, scanned)	1	1.1 (3.6)	1.5 (4.92)	1 (3.28)	1.65 (58.3)	91 (200)	120	100	5	D	1E+04	0.026 (1.5)	0.87 (50)	Class 100,000	290 ± 20	Measure sea-state (wind speed)
OP 041	IR Scanner (Thermal channel scanning radiometer)	1	1 (3.28)	1 (3.28)	1.2 (3.94)	1.2 (42.4)	43 (95)	45	20	10	D	1.5E+06	0.026 (1.5)	± 0.7 (± 40) Cross Track	Class 100,000	290 ± 20	Measure sea surface temperature ΔT to ≈ 1K
OP 042	Transponder (C-band, satellite-to-satellite)	1	0.25 (0.82)	0.2 (0.66)	0.2 (0.66)	0.01 (0.35)	8 (17.6)	20	-	-	NA	-	2.6 x 2.6 (150 x 150)	2.6 x 2.6 (150 x 150) Nadir	Class 100,000	290 ± 20	Measure satellite position, ± 1m
OP 043	Retroreflector (Optical quality glass reflectors)	1	0.61 (2)	-	0.46 (1.5)	0.0653 (2.31)	20 (44)	-	-	-	-	-	2.6 x 2.6 (150 x 150)	2.6 x 2.6 (150 x 150) Nadir	Class 100,000	273 ± 80	Measure satellite position, ± 0.1m
OP 044	Transponder (S/C-band, satellite-to-satellite)	1	0.3 (1)	0.61 (2)	0.61 (2)	0.114 (4)	40 (88)	30	20	1	NA	-	3.1 x 3.1 (180 x 180)	3.1 x 3.1 (180 x 180) Nadir	Class 100,000	290 ± 20	Measure satellite-to-satellite Position rate ± 0.0001 m/sec
OP 045	Coherent-Radar Experiment (Dual frequency, 155 & 1215 MHz altimeter)	1	0.3 (1)	1 (3.28)	1 (3.28)	0.3 (10.6)	73 (161)	140	20	1	D	8E+06	1.57 (90)	1.57 (90) Nadir	Class 100,000	290 ± 20	Measure ocean surface roughness and altitude ± 0.01m
	Mission Equipment Total					3.36 (118.8)	320 (706)	455	(Operate 50% duty cycle, operate alternate orbits)								

Prepared by: H. M. Lkerd

Table 2.1.2-1

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
2.1.3 Solar Maximum Mission (SMM)						
2.1.3.1 Mission Objectives						
The basic scientific goal of the SMM is to study the fundamental mechanisms of a solar flare.	M/2.1/5					
2.1.3.2 Mission Description	M/3.3.1/14					
Initial launch is scheduled for June 1978 on a Delta vehicle. Subsequent retrieval and re-deployment is planned for Shuttle. Minimum orbital life is 1 year. The nominal orbit is 275-300 n/mi. circular at an inclination of 28-33 degrees.	Q/ -/ - 1	●				●
2.1.3.3 Payload Instruments	M/-/-					
See table 2.1.3-1.						

7

TABLE 2.1.3-1

CANDIDATE PAYLOAD INSTRUMENTS FOR INITIAL SMM

Experiment Title [4]	Sensor Solar Facing Size cm (inch)	Sensor Length m (ft)	Sensor Weight Kg (lbs)	Sensor Unobstructed View Angle (deg)	Sensor Alignment Accuracy [5]	Electronics Volume/Weight m^3/Kg (ft^3/lb)	Day-time Power [6] (watts)	Data Rate (bps)	Discrete/Serial Cmd. Req.	Analog/Digital Telemetry Channels
UV Magnetograph	18.5 x 25.4 (7 x 10)	1.84 (6)	45 (100)	2	5 arc sec	.03m^3/16 Kg (1(ft^3)/35 lbs)	20	500	24/4	24/6
EUV Spectrometer	25.4 x 25.4 (10 x 10)	(1.84) 6	45 (100)	2	5 arc sec	.03/16 (1/35)	20	1000	24/4	24/6
High Resolution X-Ray Spectrometer	18.8 x 25.4 (7 x 10)	1.99 (6.5)	45 (100)	5	5 arc sec	.03/16 (1/35)	15	350	20/2	24/4
Hard X-Ray Imaging	15.2 x 13.7 (6 x 5)	1.99 (6.5)	45 (100)	5	10 arc sec	.03/16 (1/35)	15	200	20/2	12/3
Low Energy X-Ray Polarimeter Medium Energy X-Ray Polarimeter	20.3 x 20.3 (8 x 8)	.92 (3)	7.3 (16)	5	1 arc min	.014/9 (.5/20)	10	400	24/2	24/4
Gamma Ray Detector	45.7 x 45.7 (18 x 18)	.92 (3)	90 (200)	20	1 deg	.03/16 (1/35)	12	500	24/2	20/3
Hard X-Ray Spectrometer	30.4 x 30.4 (12 x 12)	.92 (3)	31.6 (70)	20	1 deag	.03/16 (1/35)	12	500	24/2	20/3
Solid State X-Ray Detector	30.4 x 30.4 (12 x 12)	.31 (1)	9 (20)	10	1 deg	.014/9 (.5/20)	5	1.2 200	12/1	12/2
Coronagraph	12.7 x 30.4 (5 x 12)	1.84 (6)	45 (100)	20	2 arc min	.014/9 (.5/20)	10	500	24/1	12/2
UV Spectrometer	20.3 x 30.4 (8 x 12)	1.84 (6)	50 (110)	2	5 arc sec	.03/16 (1/35)	20	500	24/4	24/6
Electron Detector	25.4 x 50.8 (10 x 20)	.92 (3)	93 (205)	20	1 deg	.03/16 (1/35)	15	200	24/2	20/2
H-Photometer	10.2 x 10.2 (4 x 4)	.92 (3)	9 (20)	2	5 arc sec	.014/9 (5/20)	10	125	12/1	10/1
Flare Finder	10.2 x 10.2 (4 x 4)	1.84 (6)	13.5 (30)	2	10 arc sec	.014/9 (.5/20)	10	50 [3]	12/1	10/1

REMARKS:

1 - Needs a cold plate.
2 - Bit rate requirement is orbital average. Typical requirement is 6000 bps for one minute per flare.
3 - Bit rate requirement is orbital average. Typical requirement is 1000 bps for one minute per flare.
4 - SMM shall accommodate all of these experiments simultaneously.
5 - Indicates relative alignment accuracy between the instrument and the fine pointing sun sensor.
6 - Nighttime power requirements approximately 20% of daytime power.

REQUIREMENT	SOURCE	1	2	3	4	5	A	B	C	D	E
2.1.4 SEOS Mission											
2.1.4.1 Mission Requirement	L/EO-09A/5-34 (TS 2.17)				●						
The SEOS mission is intended to investigate remote sensing techniques for measuring transient environmental phenomena from a geosynchronous orbit.											
2.1.4.2 Mission Description	L/EO-09A/5-34				●						
Nominal mission altitude will be 19323 n.mi circular at an inclination of 0 degrees. Nominal orbit positioning will be 96° west longitude. Nominal mission duration is to be 2 years with initial launch scheduled for CY 1981. Recovery and/or on-orbit servicing is not planned.											
The EOS shall be capable of placing the SEOS experiments in an equatorial orbit of the following characteristics: $ha = 19323 \pm 25$ n.mi; $hp = 19323 \pm 25$ n.mi; $i = 0 \pm 0.2$ deg.	L/EO-09A/5-34				●						
The EOS shall place the SEOS experiments at a nominal orbit position of 96° west longitude.	L/EO-09A/5-34				●						
The EOS shall maintain the SEOS experiments on-orbit for not less than 2 years.	L/EO-09A/5-34										
The EOS shall support an initial launch of SEOS experiments in CY 1981.	L/EO-09A/5-34				●						
2.1.4.3 Payload Instruments											
Prime instrument for this mission is the Large Earth Survey Telescope (LEST). Other instruments being considered are: Advanced Atmosphere Sounder & Imaging Radiometer (AASIR), Microwave Sounder, Data Collection System, Framing Camera	AL/-/-				●						

REQUIREMENT	SOURCE	1	2	3	4	5	A	B	C	D	E	F
2.1.5 TIROS O Mission												
Mission Objectives	L/EO-12A/A-2 (TS 2-17)			●							●	
The TIROS O vehicle is intended to verify for operational use an advanced environmental operation payload. This spacecraft will have implemented operational versions of remote sensing techniques proven in nimbus and EOS flight experiments as well as improvements in those sensors carried by the previous N/ITOS vehicles. The TIROS O satellite will be the first of the operational vehicles to be designed with the shuttle exploitive modular design so that in orbit refurbishment of the payload can be effected and evaluated.												
Mission Description	L/EO-12A/A-1			●							●	
Nominal perigee altitude of 905 nmi (1676 km) and apogee of 915 n mi (1695 n mi) at an inclination of 103°.												
Payload Instruments	AI/-/5-66			●							●	
See table 2.1.5-1.												

MISSION EQUIPMENT

Data Sheet No. A-8
Payload No. EO-12A
Date 9/5/73 Rev. ORIG.

Payload Name TIROS O

1. Ref. No.	2. Name	3. Qty	UNIT SIZE, m (ft) 4. Width or Dia.	5. Height	6. Length	7. UNIT VOLUME, m^3 (ft^3)	8. UNIT WEIGHT, kg (lb)	UNIT POWER Level, watts 9. Average	10. Peak	11. Peak Duration, sec.	UNIT DATA OUTPUT 12 Form: A, D, film	13 Rate, Hz, b/s, frames	FIELD OF VIEW, radians (degrees) 14 Instantaneous	15 Total	ENVIRONMENT CONSTRAINTS 16. Contam. Sensitivity	17. Temp, °K	18. REMARKS
EO-95	ADVANCED VERY HIGH RESOLUTION RADIOMETER	2	0.31 D (1)		0.82 (2.7)	0.06 (2.12)	27.2 (60)	15			D	1.0E+06 b/s	5.5E-04 (0.0315)	2.19	CLEANLINESS CLASS 10,000 DEPOSITION OF WATER VAPOR ON OPTICAL SURFACES.		
EO-96	ADVANCED TIROS OPERATIONAL VERTICAL SOUNDER	2	0.46 (1.5)	0.31 (1.0)	0.70 (2.3)	0.10 (3.5)	45.6 (100)	60			D	4000 b/s	0.0197 (1.125)	1.42 (81)			
EO-97	SCANNING MULTICHANNEL MICROWAVE RADIOMETER																
	ELECTRONICS	2	0.31 (1.0)	0.31 (1.0)	0.31 (1.0)	0.030 (1.0)	52.2 (115)	85				1500 b/s	0.020 (1.16)	±0.61 (±35)			CONICAL SCAN
	SCANNER	1	1.0 D (3.28)		0.5 (1.64)	0.39 (13.9)											
EO-98	MICROWAVE RADIOMETER/ SCATTEROMETER																
	ELECTRONICS	1	0.348 (1.14)	0.348 (1.14)	0.348 (1.14)	0.042 (1.48)	36.3 (80.0)				D	10,000b/s	0.013 (0.74)	(1.05) (60)			
	ANTENNA	1	0.27 (0.88)	0.02 (0.07)	0.27 (0.88)	0.0015 (0.054)	20.4 (44.9)	92									
EO-99	CLOUD PHYSICS RADIOMETER	2	0.23 (0.75)	0.23 (0.75)	0.46 (1.5)	0.024 (0.84)	13.6 (30)	20			D	3.0E+04 b/s	0.0025 (0.14)	± 1.3 (± 75)			
EO-100	SPACE ENVIRONMENTAL MONITOR	2	0.27 (0.9)	0.27 (0.9)	0.27 (0.9)	0.020 (0.73)	11.4 (25)	6			D	120 b/s	3.15 (180)				
EO-101	DATA COLLECTION SYSTEM	2	0.15 (0.5)	0.20 (0.67)	0.51 (1.67)	0.015 (0.55)	22.7 (50)	10			D	800 b/s					

SSPD (A-3) 3-12-73

Prepared by L. KRAWITZ

Table 2.1.5-1

REQUIREMENT	SOURCE	OPTION
2.2 Traffic Model	AJ/-/4	

Mission	Purpose	Booster Option	S/C Payload	Launch Date	1	2	3	4	5	A	B	C	D	E	F
A	LRM	1 (Delta 2910)	MSS, TM, DCS	'79	●					●					
A'	LRM	1 (Delta 2910)	MSS, TM, DCS	'80	●					●					
Test	Demo Rendez docking & resupply	5 (Shuttle)	Eng. Model	'80					●						
B	LRM	2 (WCT)*	TM, HRPI, DCS	'81		●					●				
B'	LRM	2 (WCT)	TM, HRPI, DCS	'82		●					●				
C	Marine Resources	3 (Titan IIIB)	2TM, HRPI, SAR, DCS	'80			●					●			
D	Ocean Dynamics	1 (Delta 2910)	(SEASAT-B)	'82	●								●		
E	Weather Observation	3 (Titan IIIB)	(TIROS-O)	'82			●							●	
F	Transient Environmental phenomena	4 (Titan IIIC)	(SEOS-A)	'81				●							●

(TS 16)

(TS 2)

* Weight Constrained Titan

ORIGINAL PAGE IS OF POOR QUALITY

REQUIREMENT		SOURCE	OPTION 2.23.5
2.3	SHUTTLE RELATED PERFORMANCE		
2.3.1	Shuttle launch azimuth and orbit inclination limits are as shown in Fig. 2.3-1	AC/3.2.2/3.3	•
2.3.2	Shuttle performance capabilities are defined in:		•
	o Figs. 2.3-2 through -7	AC/3.2.3.1/3-4	
	o Fig. 2.3-8	AC/3.2.3.2/3-4	
	o Fig. 2.3-9	AC/3.2.3.3/3-5	

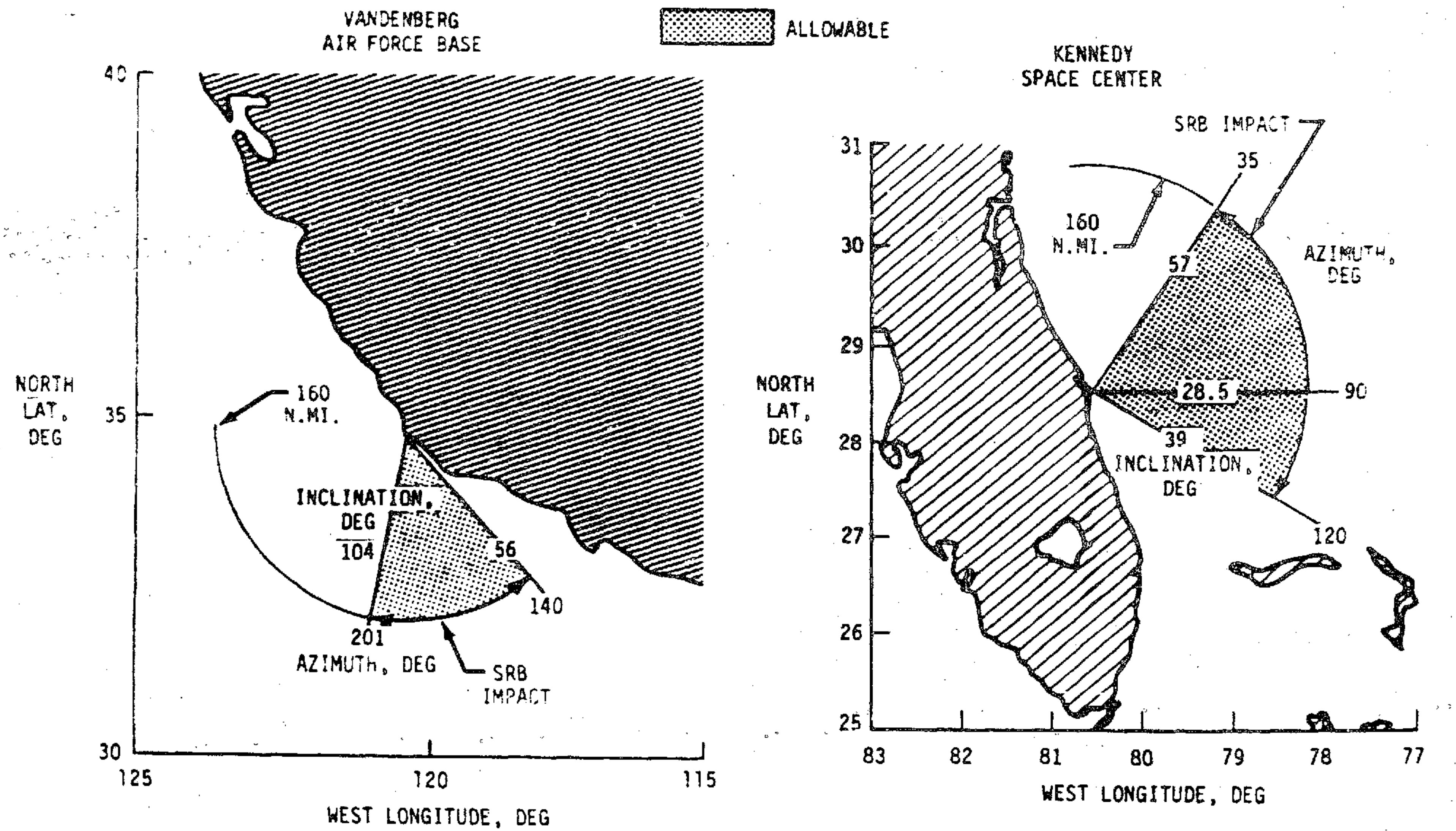


Fig. 2.3-1 LAUNCH AZIMUTH AND INCLINATION LIMITS FROM VAFB AND KSC

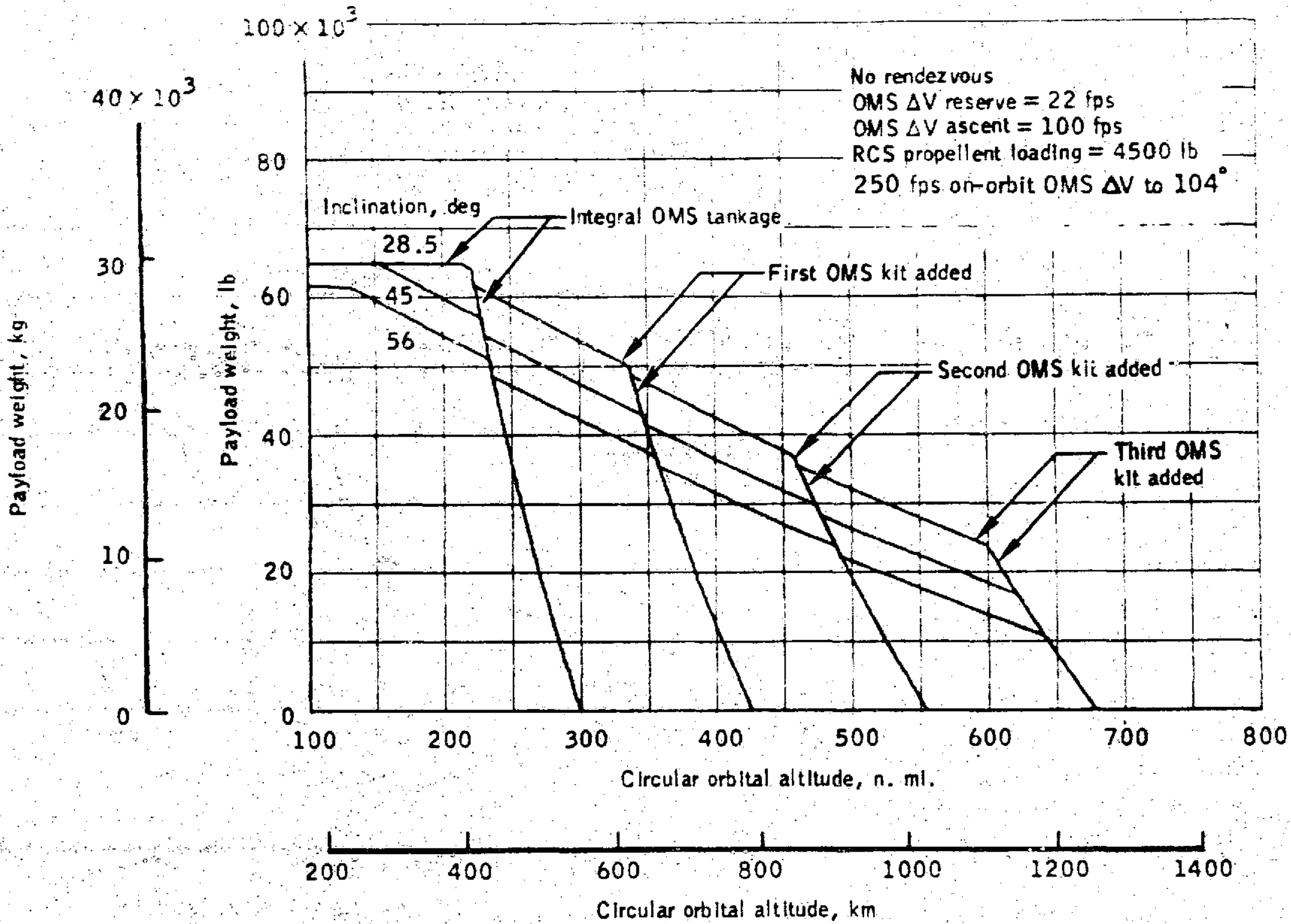


Fig. 2.3-2 - Payload weight versus circular orbital altitude - KSC launch, delivery only.

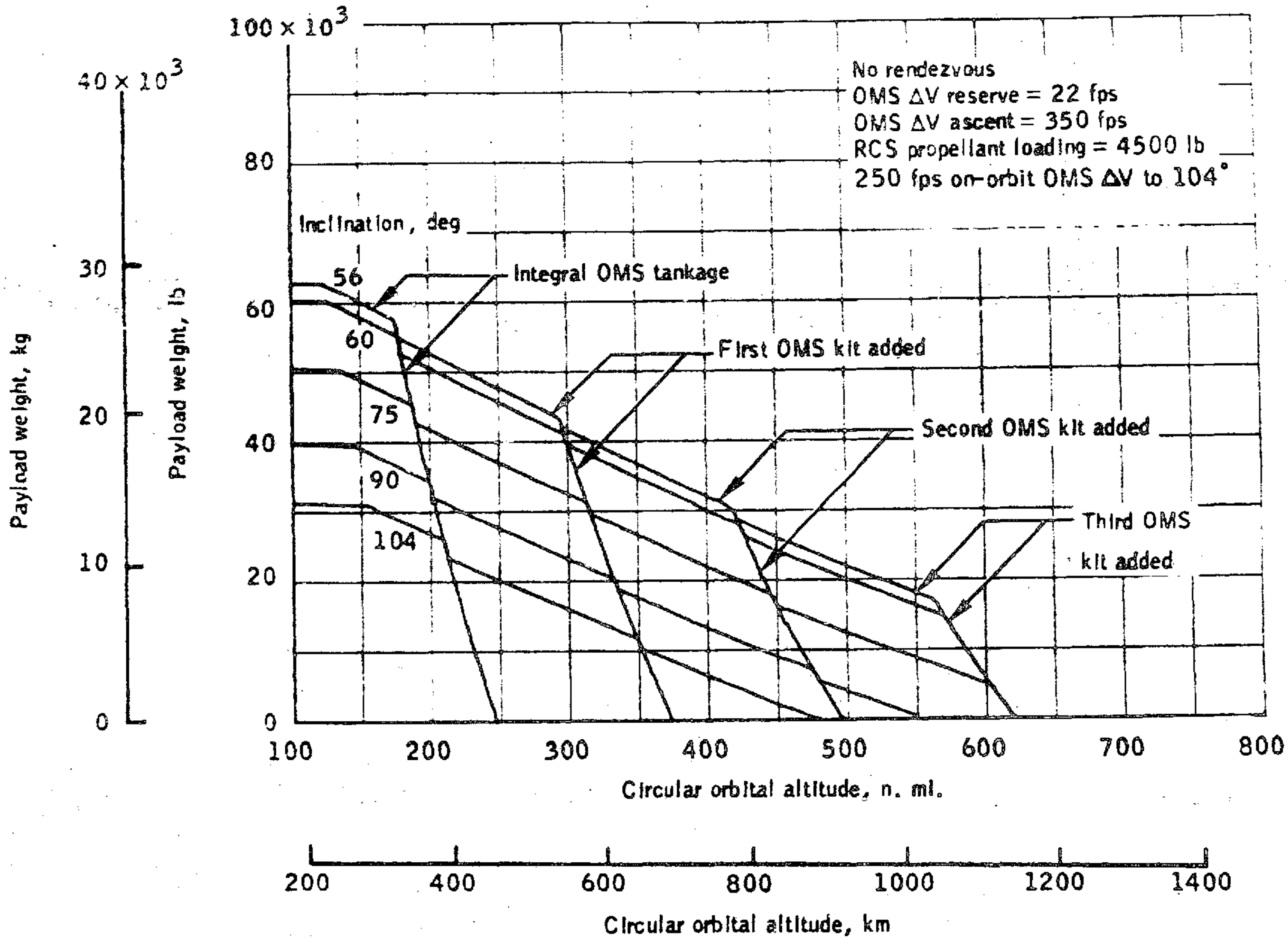


Fig. 2.3-3 – **Payload weight versus circular orbital altitude – VAFB launch, delivery only.**

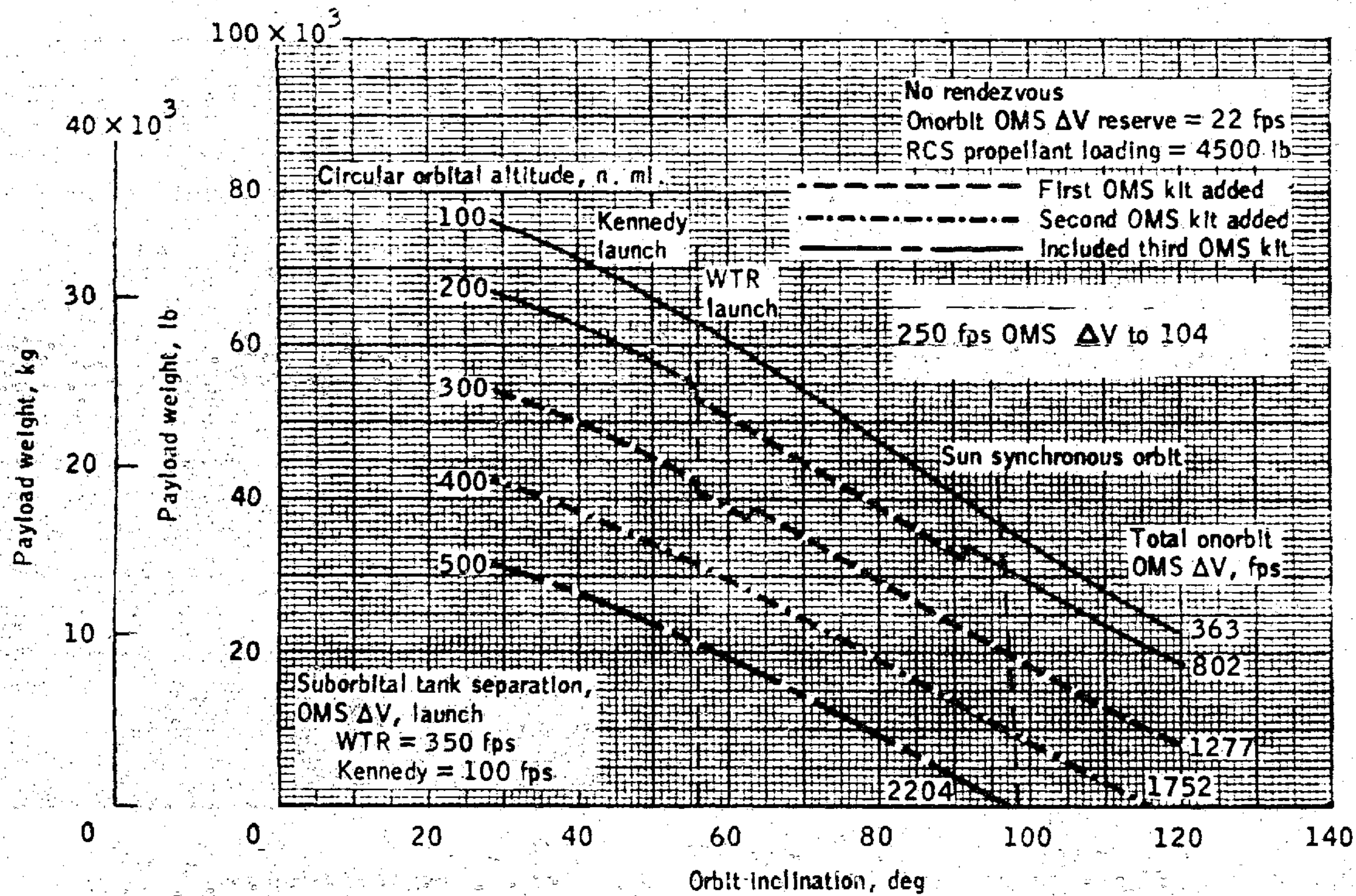


Fig. 2.3-4 - Payload weight versus inclination for various circular orbital altitudes - delivery only.

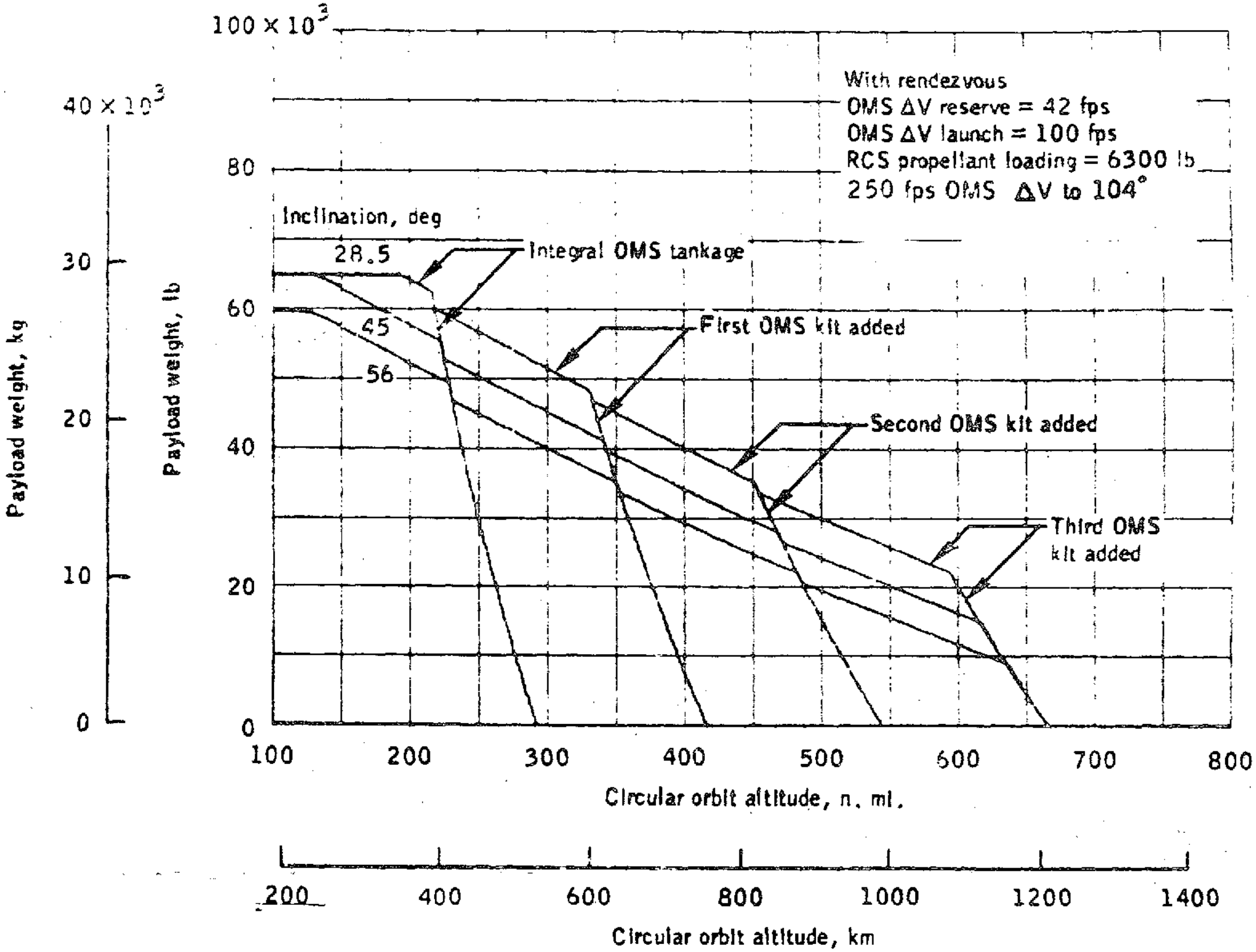


Fig. 2.3-5 - Payload weight versus circular orbital altitude - KSC launch, delivery and rendezvous.

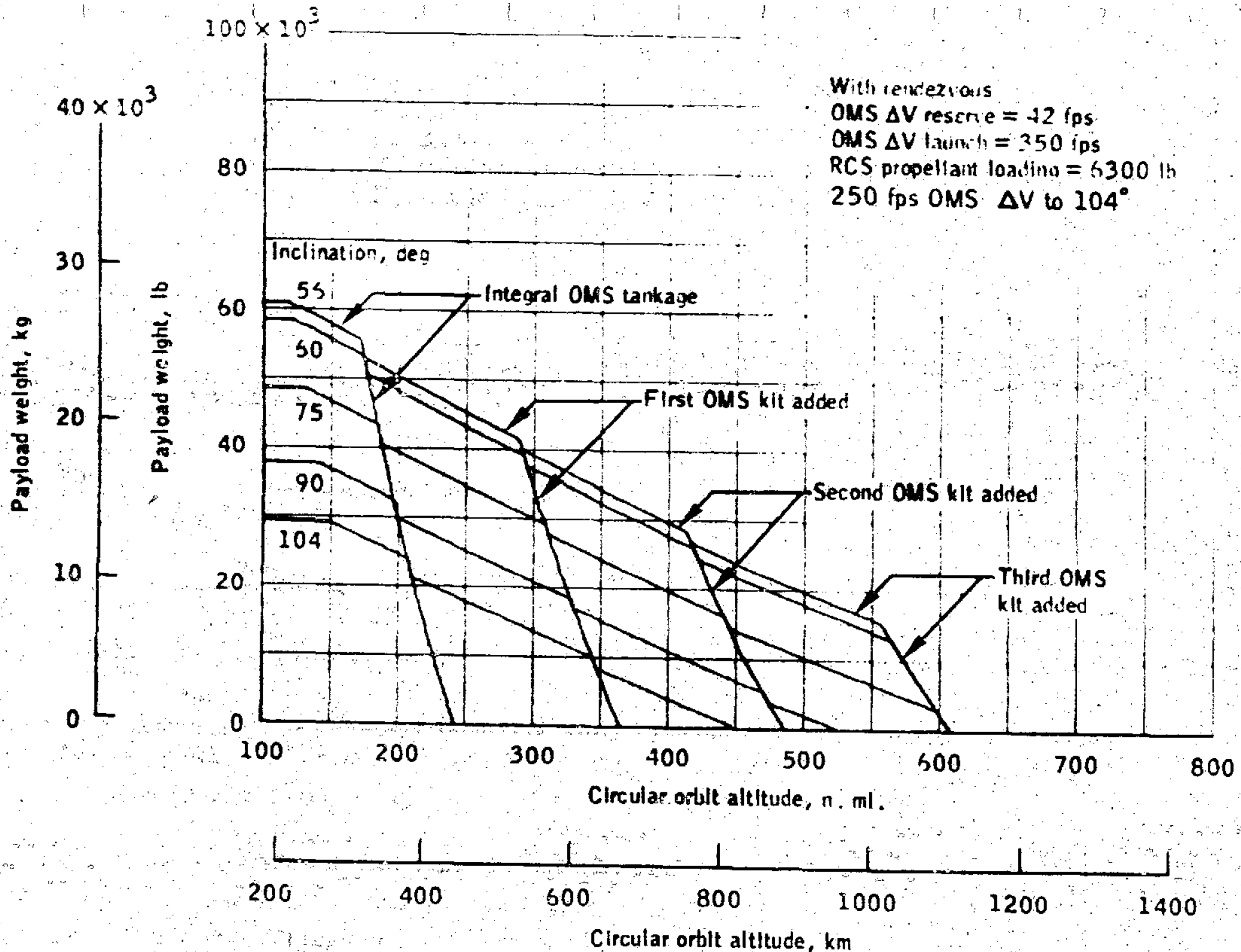


Fig. 2.3-6 .- Payload weight versus circular orbital attitude - VAFB launch, delivery and rendezvous.

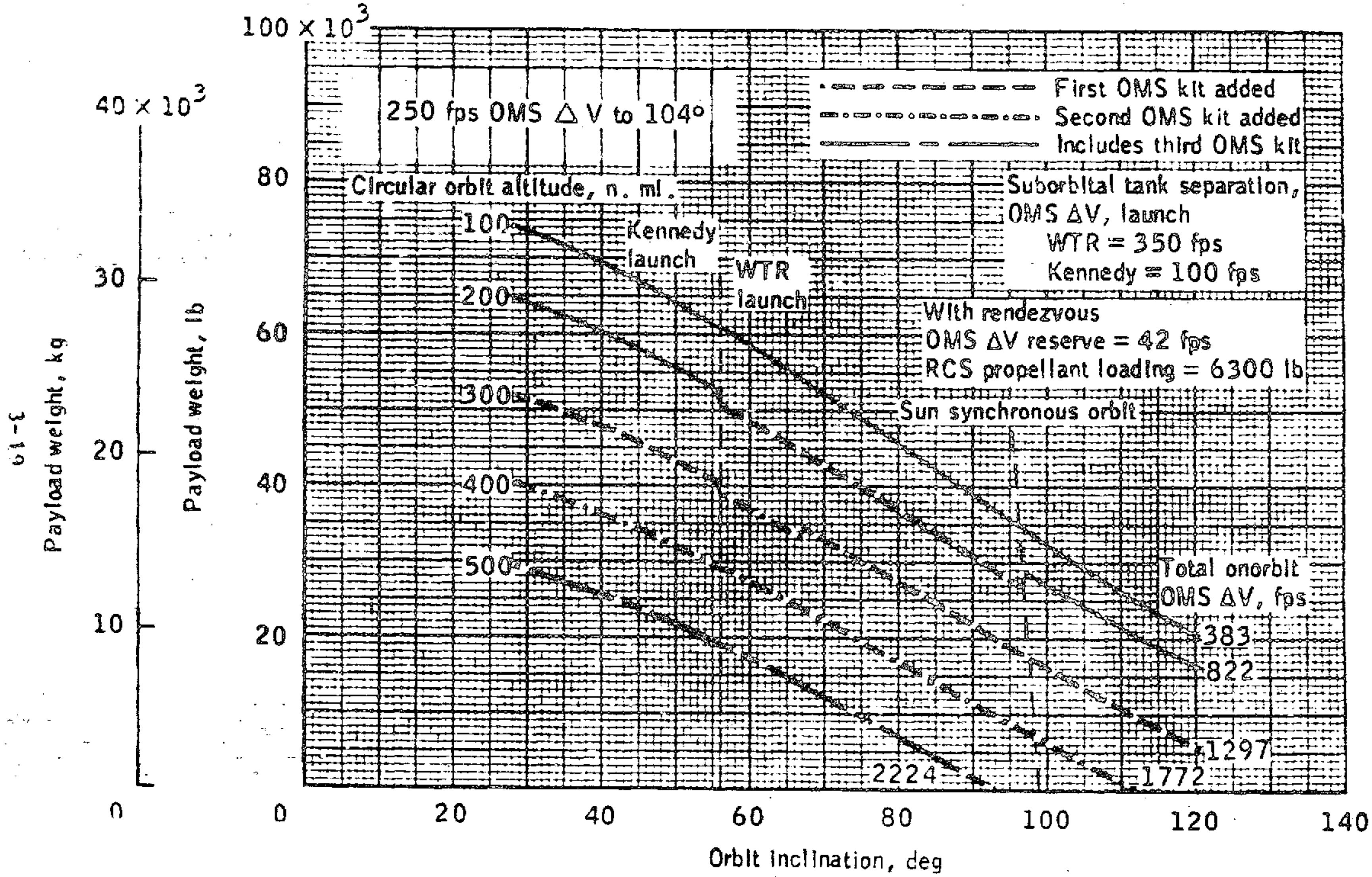


Fig. 2.3-7 - Payload weight versus inclination for various circular orbital altitudes - delivery and rendezvous.

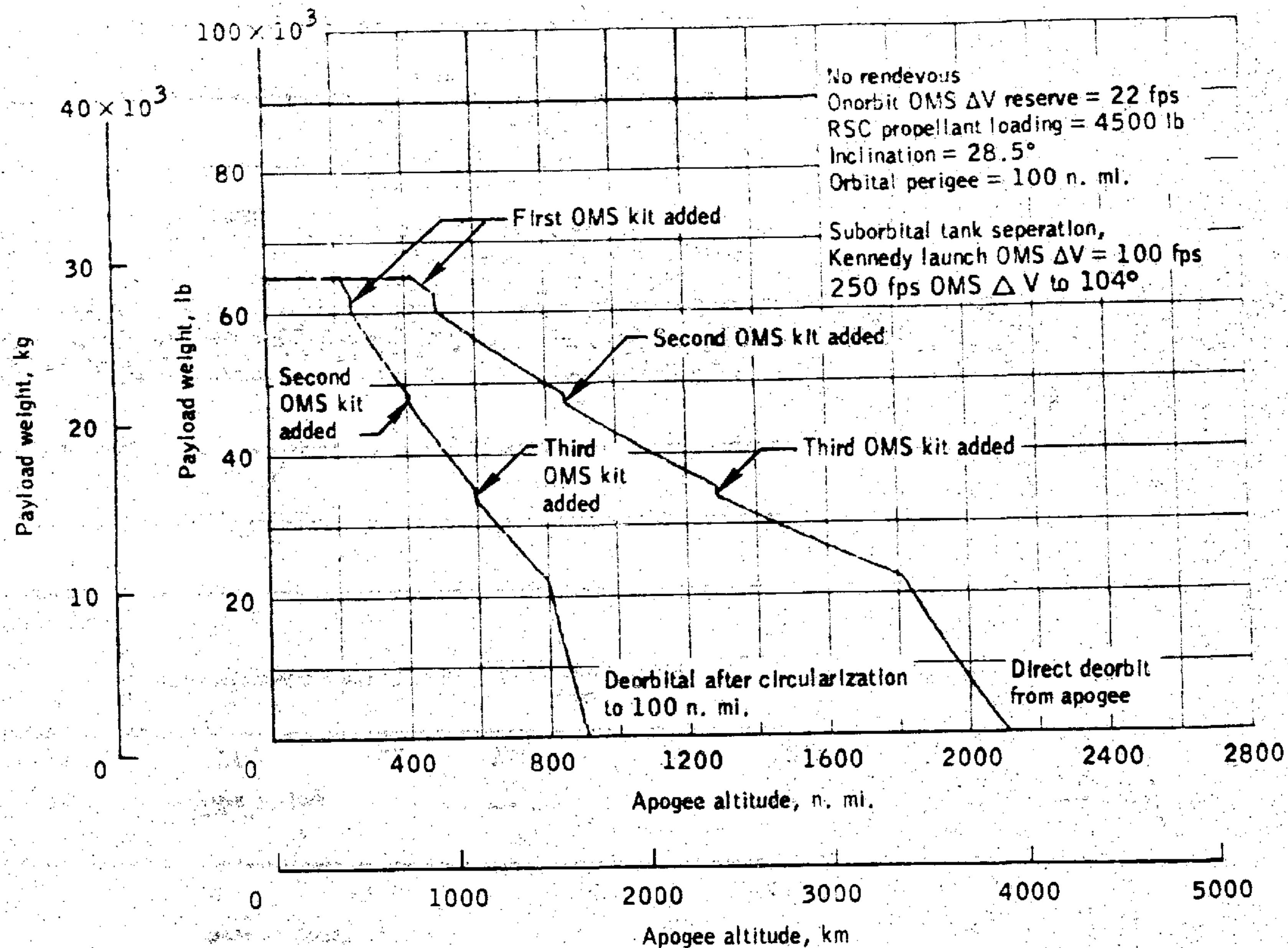


Fig. 2.3-8 - Payload weight versus elliptical orbital altitude.

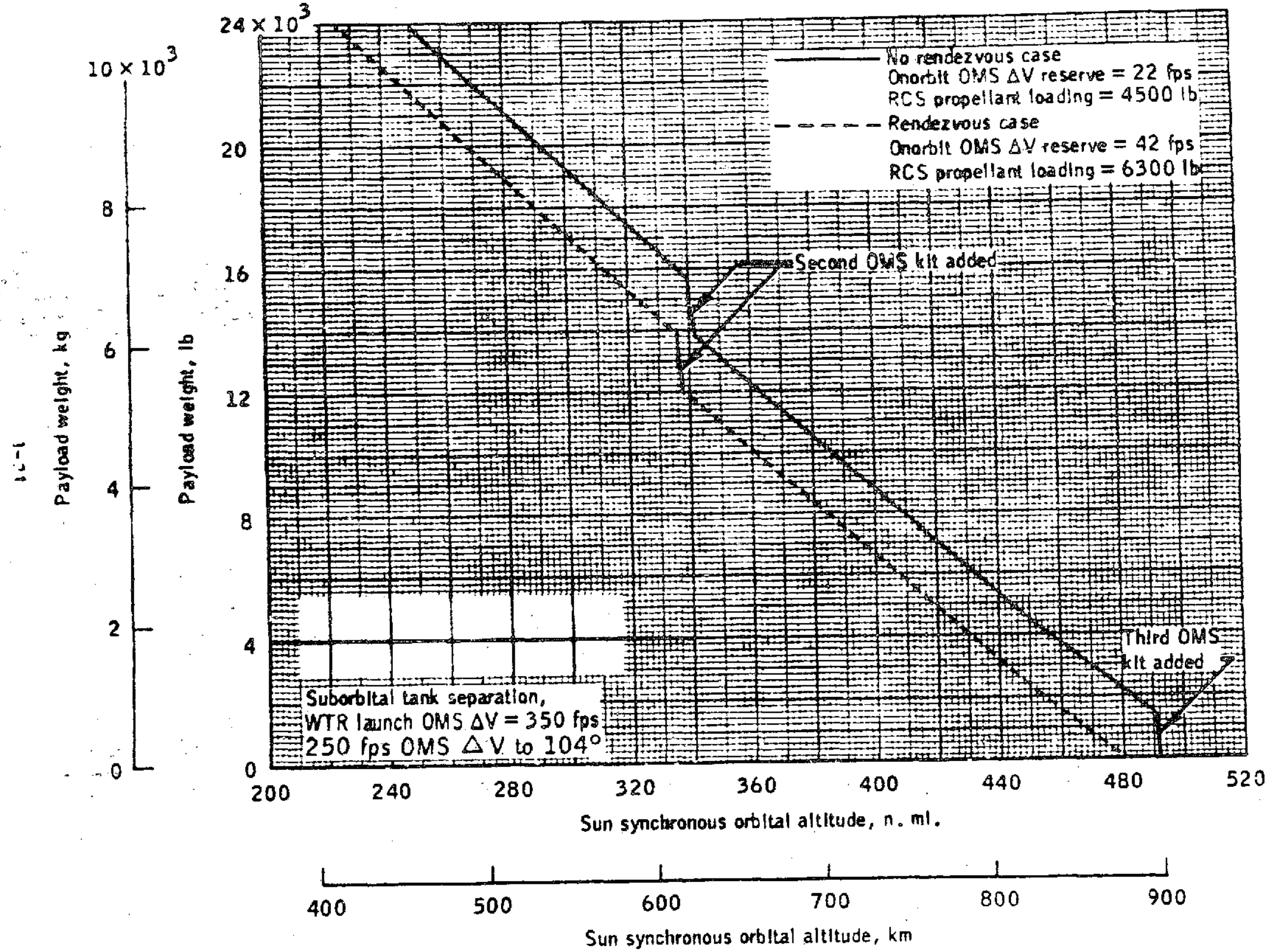
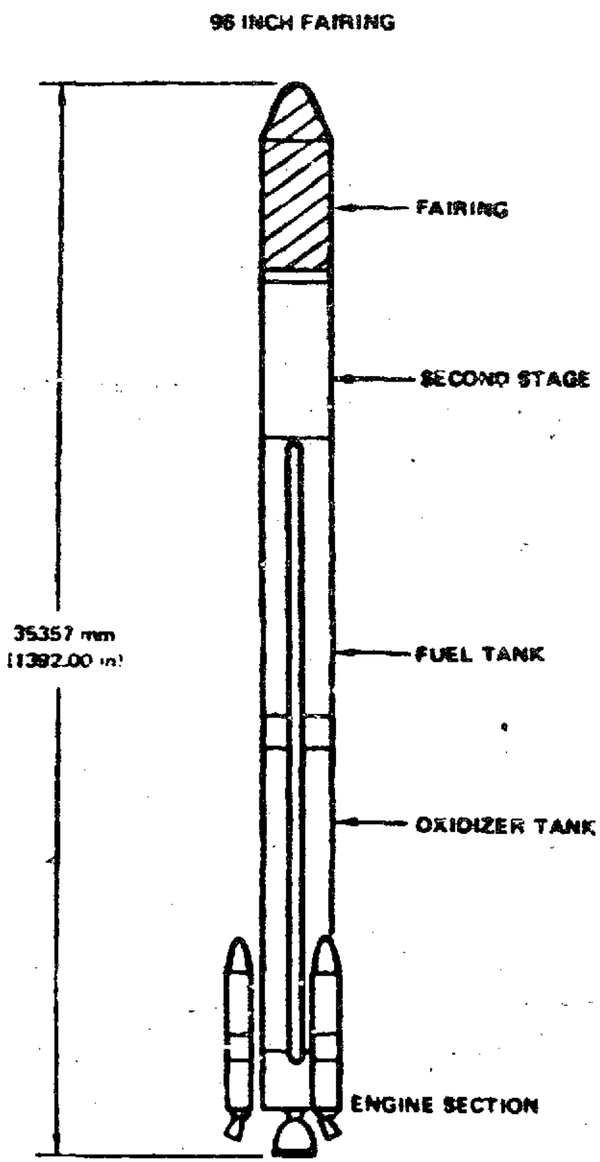


Fig. 2.3-9- Payload weight versus sun synchronous orbital altitude.

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
2.6.1 Delta 2910						
2.6.1.1 General vehicle characteristics are as defined in Fig. 2.6.1-1	T/Fig 1-3/1-5 T/1.2.1/1-4	●				
2.6.1.2 Vehicle performance capabilities are as defined in Figures 2.6.1-2 through -6	T/Fig 2-1/2-2 T/Fig 2-4/2-5 T/Fig 2-7/2-10 T/Fig 2-11/2-14	●				



Hardpoints - TBD

Guidance - TBD

Stage II - Delta vehicle (96 in/2438 mm diam) with TRW Systems TR-201 propulsion system.

- Propellants loaded - TBD
- I_{sp} nominal - TBD
- Thrust - TBD
- Loaded weight - TBD

Stage I - Extended Long Tank Thor with Rocketdyne RS-27 engine

- Propellants loaded - TBD
- I_{sp} nominal - TBD
- Thrust - TBD
- Loaded weight - TBD

Stage 0 - Nine Castor II (TX-354-5) SRM's

- Impulse propellant - TBD
- TVC loaded - TBD
- I_{sp} average - TBD
- Total impulse - TBD
- Loaded weight - TBD

Liftoff

- Weight - TBD
- Thrust - TBD

Fig. 2.6.1-1 Vehicle Characteristics, Delta 2910

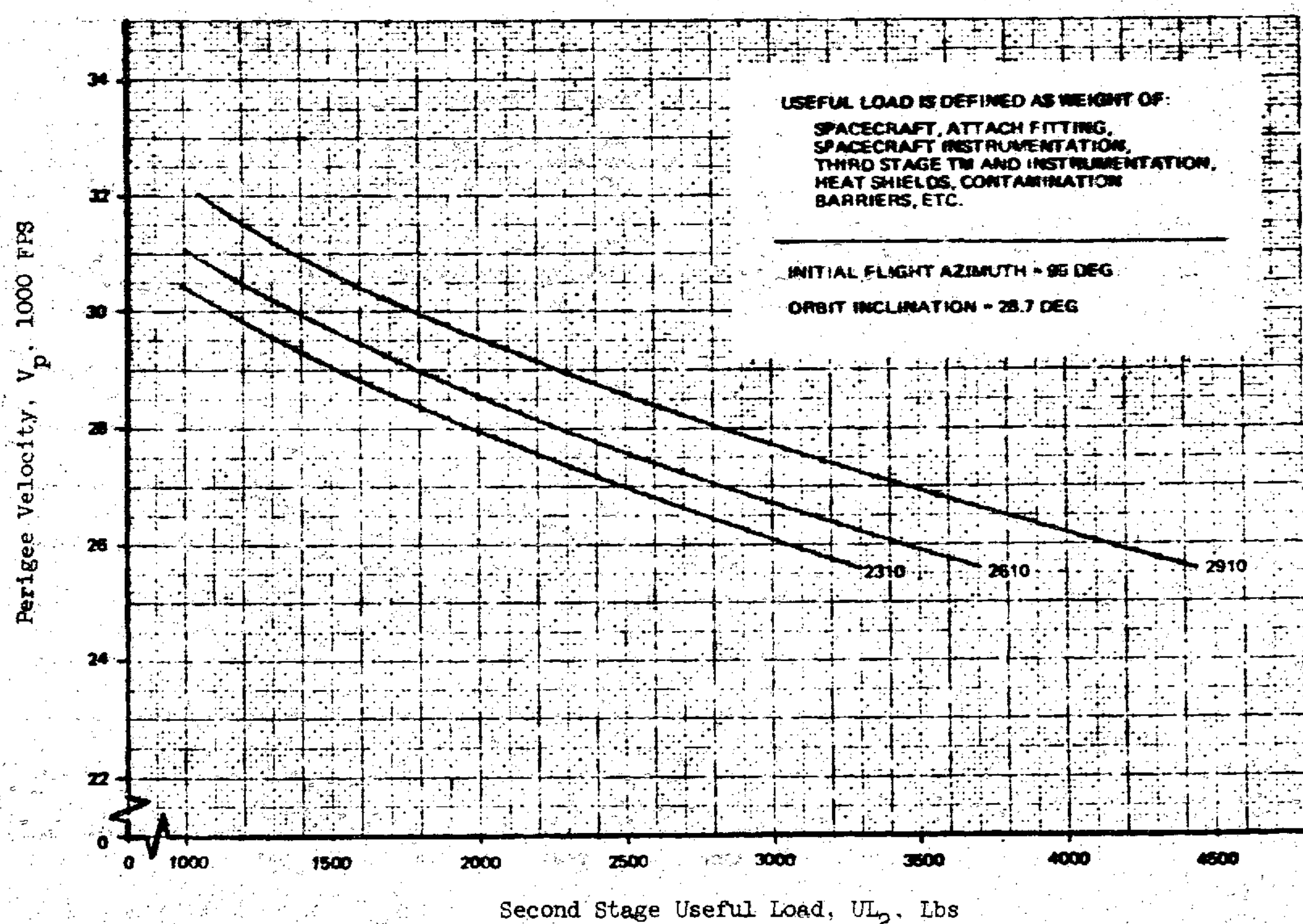


Fig. 2.6.1-2 Two Stage Perigee Velocity, 100 n.mi Perigee Altitude, ETR

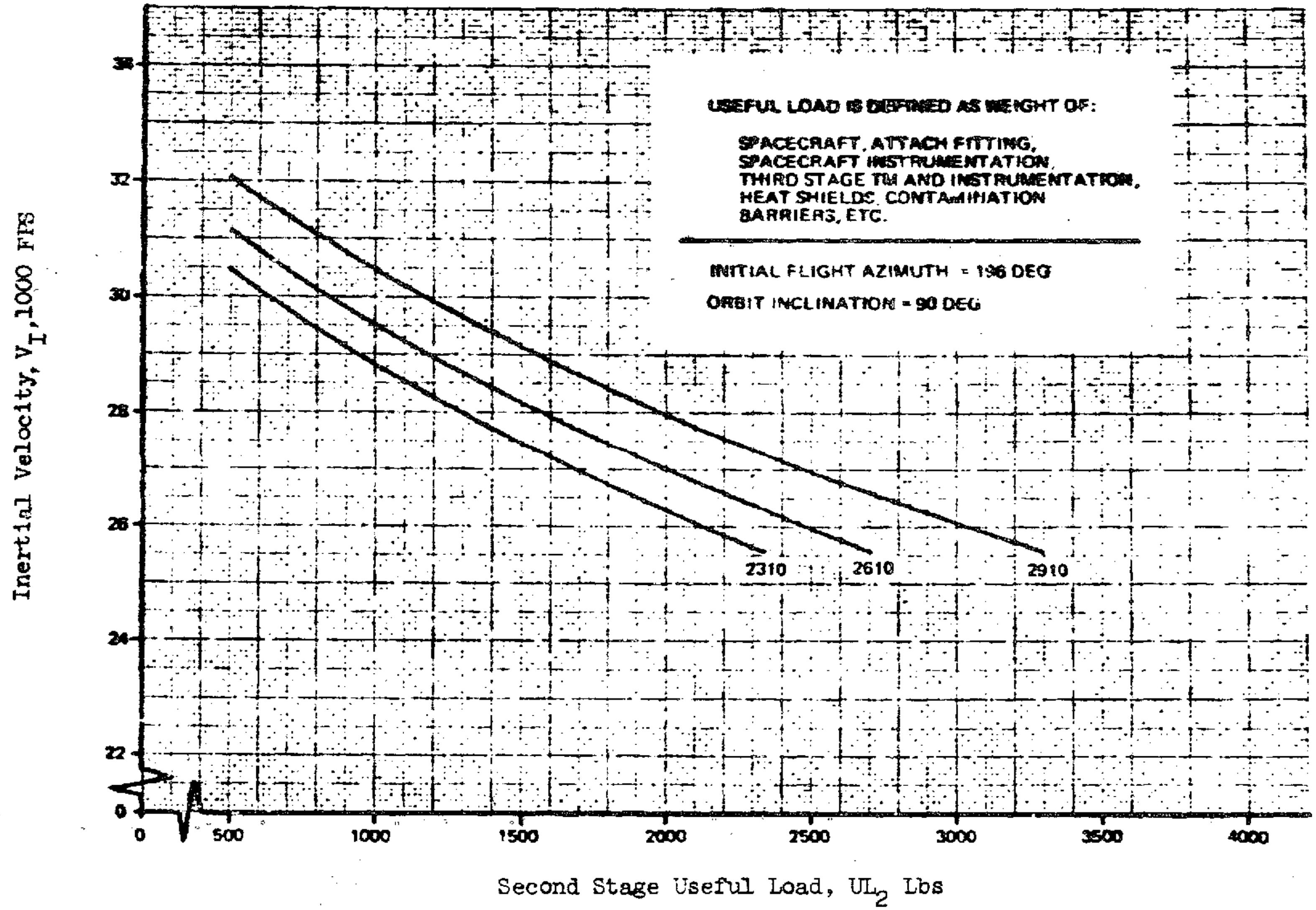


Fig. 2.6.1-3 Two Stage Perigee Velocity, 100 n.mi Perigee Altitude WTR

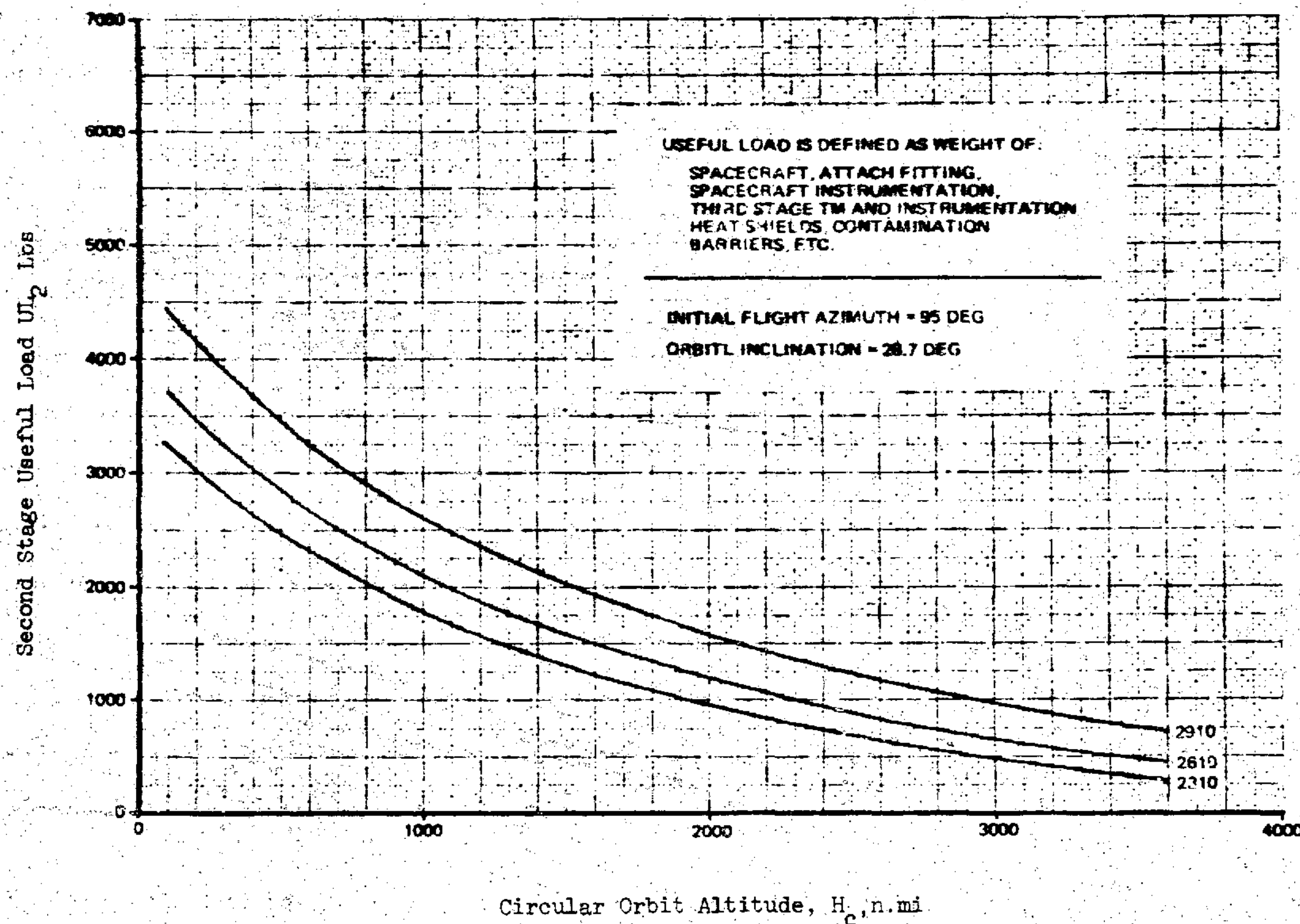


Fig. 2.6.1-4. Sun Synchronous Orbit Capability. ETR

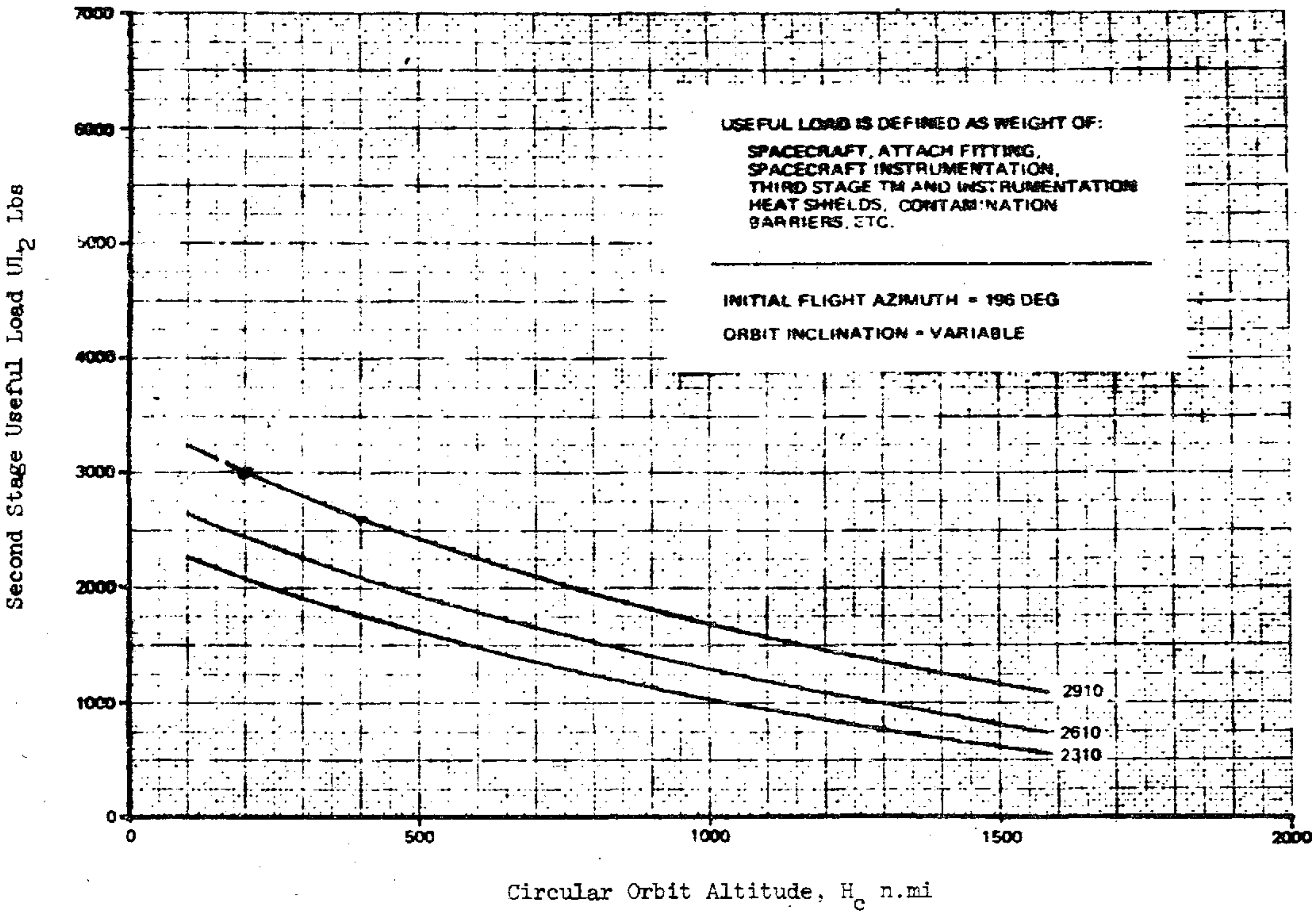
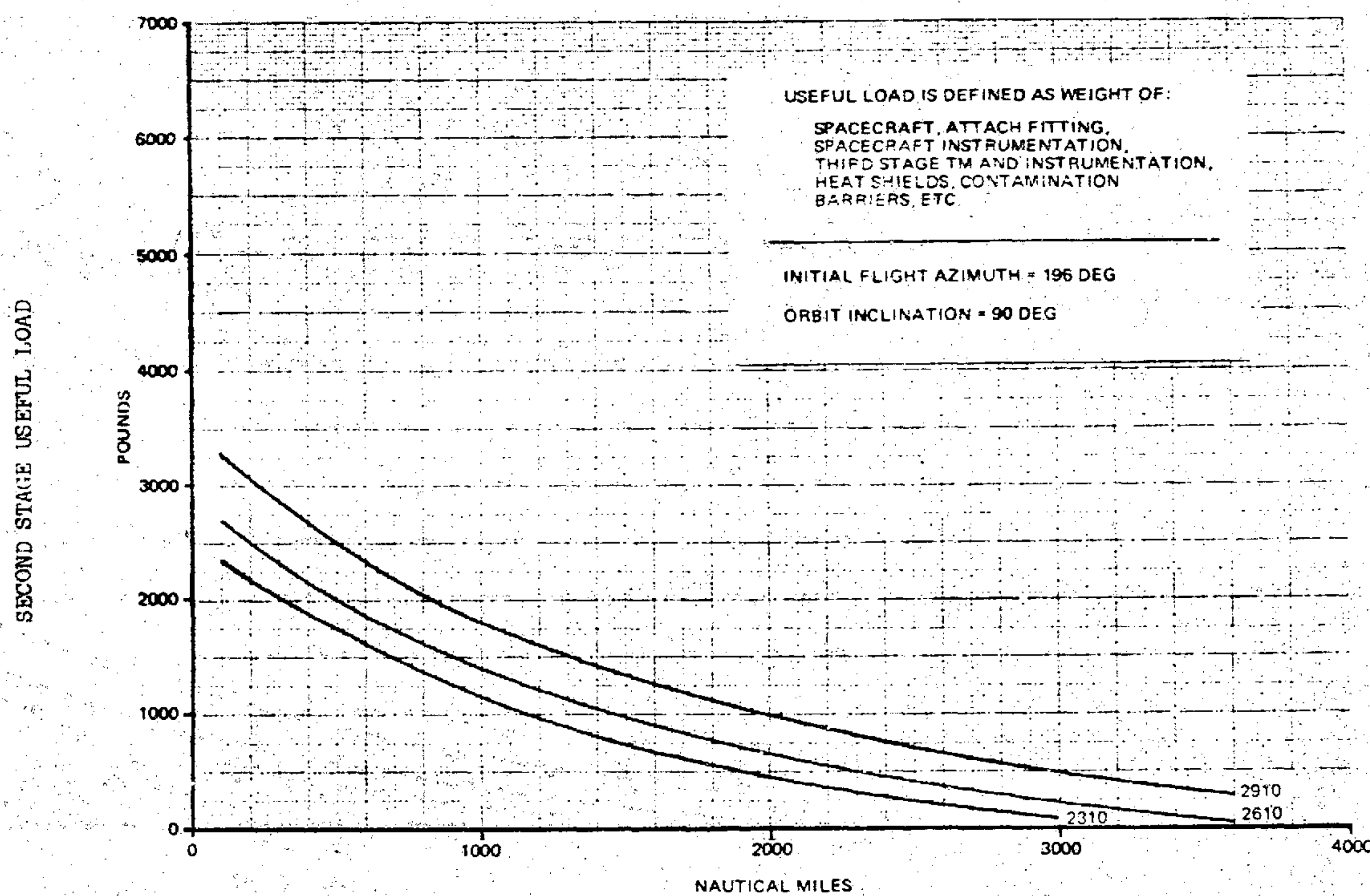


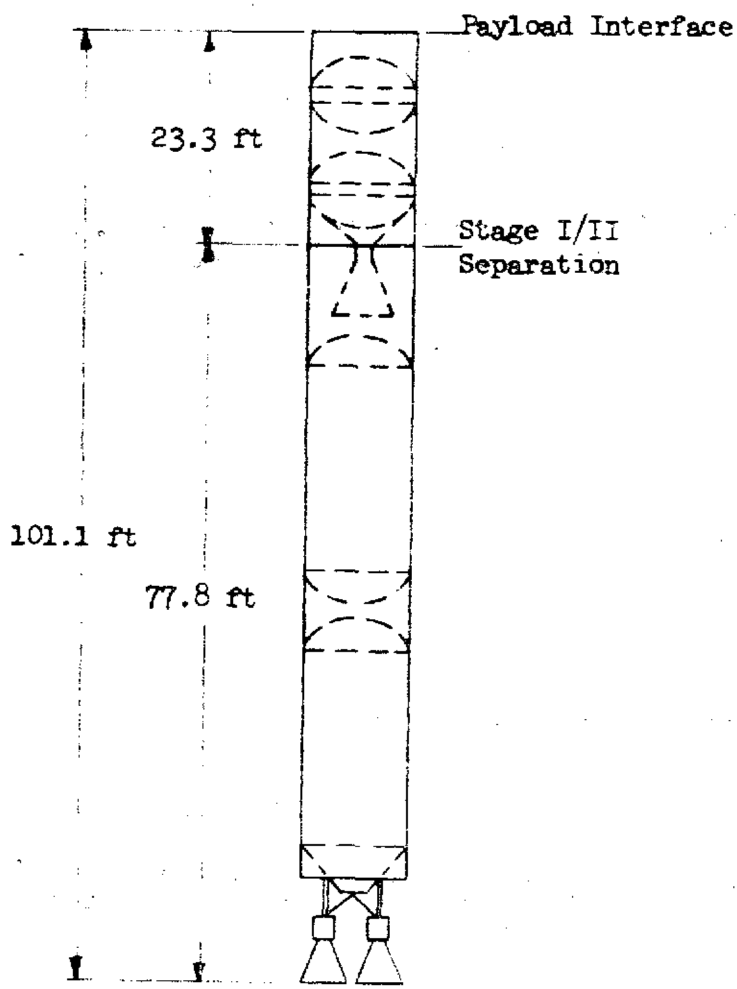
Fig. 2.6.1-5, Sun Synchronous Orbit Capability, WTR



CIRCULAR ORBIT ALTITUDE

FIGURE 2.6.1-6 CIRCULAR ORBIT CAPABILITY, WTR

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5								
2.6.2 Titan IIIB/SSB/NUS														
2.6.2.1 General vehicle characteristics are as defined in Fig. 2.6.2-1	U/Fig II-15/II-26			●										
2.6.2.2 Vehicle performance capabilities are as defined in Figures 2.6.2-2 and -3	U/Fig III-17/III-35 U/Fig III-19/III-37			●										



	ETR	WTR
Hardpoints - 12 Equally Spaced		
Guidance - Radio on Programmed Inertial		
Stage II		
Propellants Loaded, lb	67,300	67,900
I_{sp} Nominal (Vacuum), sec	319	
Thrust (Vacuum), lb	102,300	
Loaded Weight, lb	72,620	73,260
Stage I		
Propellants Loaded, lb	290,300	295,000
I_{sp} Nominal (Sea Level), sec	258	
Thrust (Sea Level), lb	463,200	
Loaded Weight, lb	304,850	309,500
Liftoff - Two Stages without Payload or Payload Fairing		
Weight, lb	373,600	378,800
Thrust, lb	462,700	

Note: Data for WTR are the same as for ETR, except as shown.

Fig. 2.6.2-1 Vehicle Characteristics, Titan IIIB(SSB), ETR and WTR

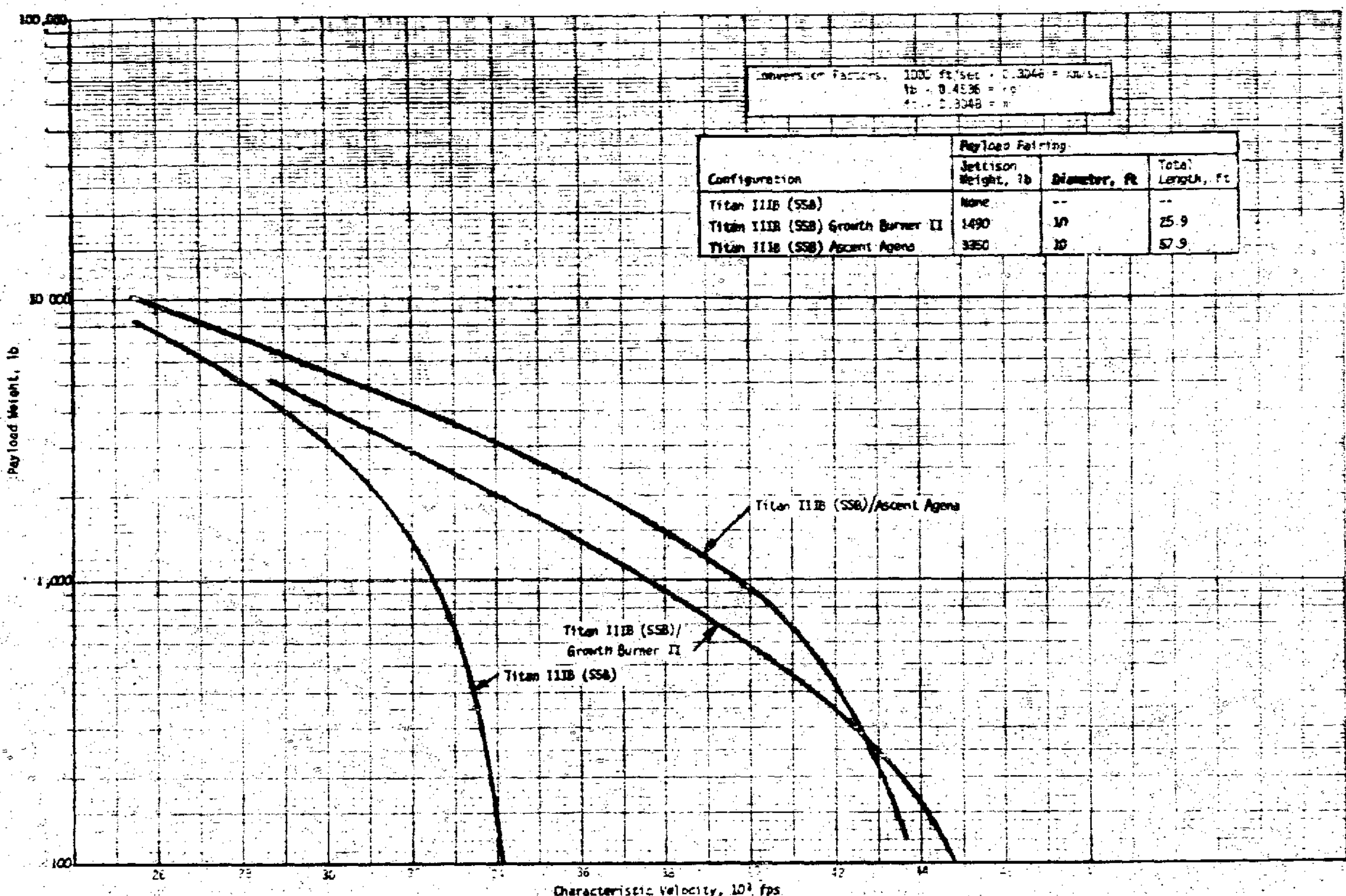


Fig. 2.6.2-2 Titan IIIB(SSB), Payload Weight vs Characteristic Velocity

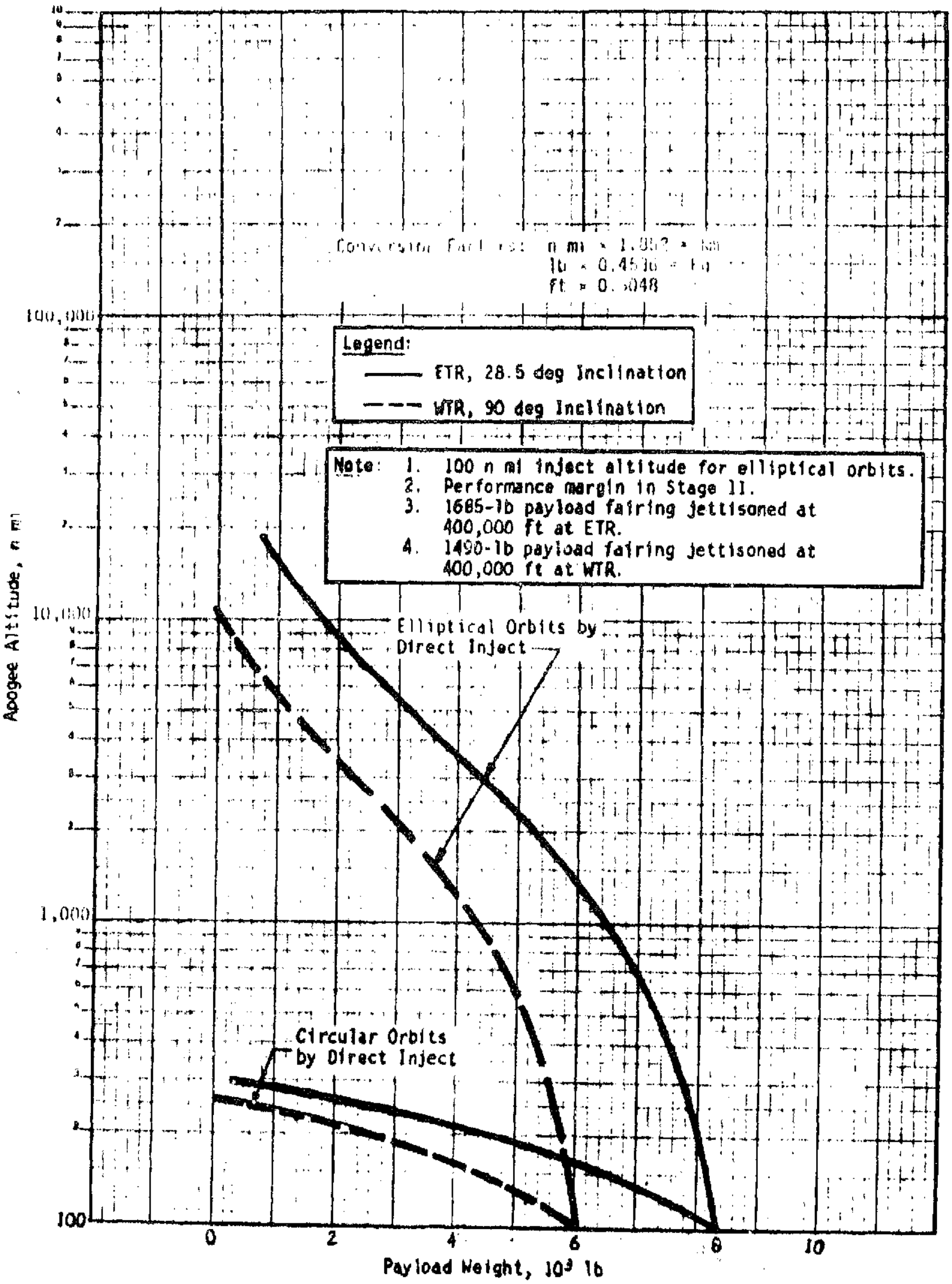
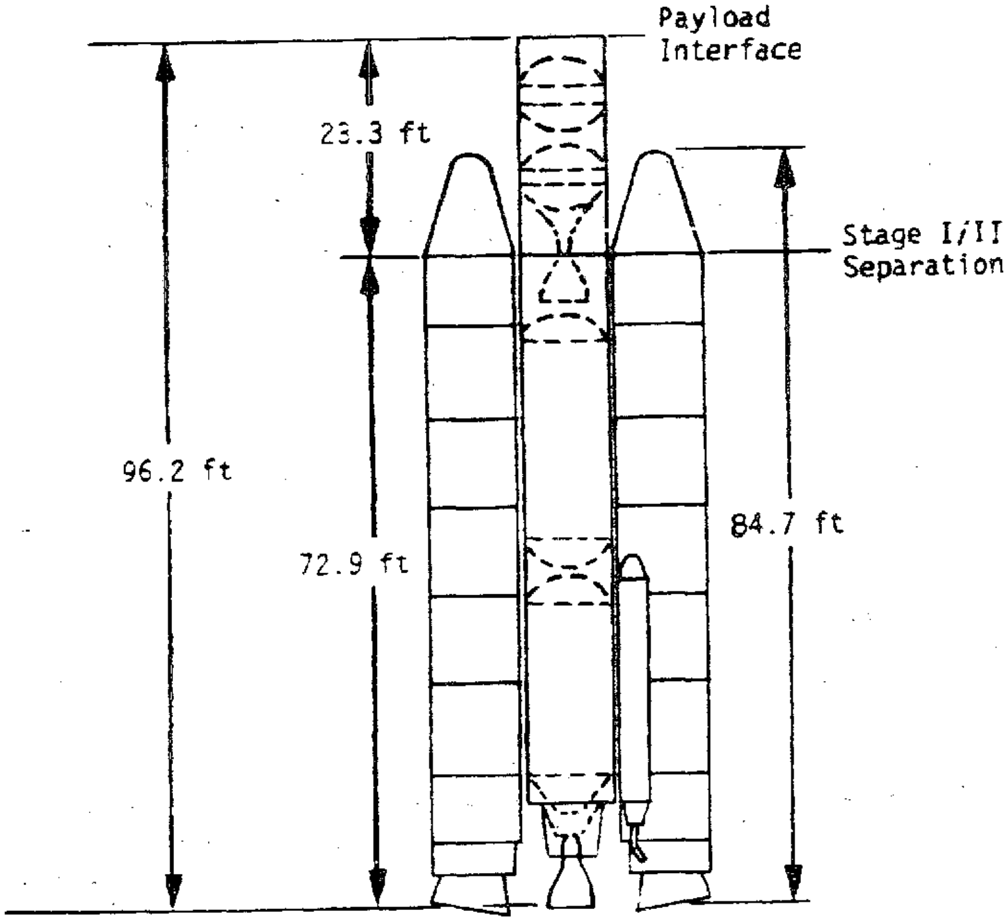


Fig. 2.6.2-3 Titan IIIB(SSB), Payload Weight vs Altitude, ETR and WTR

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
2.6.3 Titan IIID/NUS						
2.6.3.1 General vehicle characteristics are as defined in Fig. 2.6.3-1	U/Fig II-9/II-20					
2.6.3.2 Vehicle performance capabilities are as defined in Figures 2.6.3-2 and -3	U/Fig III-14/III-32 U/Fig III-15/III-33					



<u>Hardpoints</u> - 36 Equally Spaced

<u>Guidance</u> - Radio

<u>Stage II</u>

Propellants Loaded - 67,900 lb
I_{sp} Nominal - 319 sec (Vacuum)
Thrust - 102,300 lb (Vacuum)
Loaded Weight - 73,700 lb

<u>Stage I</u>

Propellants Loaded - 262,200 lb
I_{sp} Nominal - 302 sec (Vacuum)
Thrust - 526,300 lb (Vacuum)
Loaded Weight - 277,600 lb

<u>Stage 0</u> - Two 5-Segment SRMs

Impulse Propellant - 850,100 lb
TVC (N_2O_4) Loaded - 16,850 lb
I_{sp} Average - 266 sec (Vacuum)
Total Impulse - 226.1 x 10^6 lb-sec (Vacuum)
Loaded Weight - 1,017,800 lb

<u>Liftoff</u> - Three Stages without <u>Payload</u> or Payload Fairing

Weight - 1,368,100 lb
Thrust - 2,295,200 lb

Fig. 2.6.3-1 Vehicle Characteristics, Titan IIID, WTR

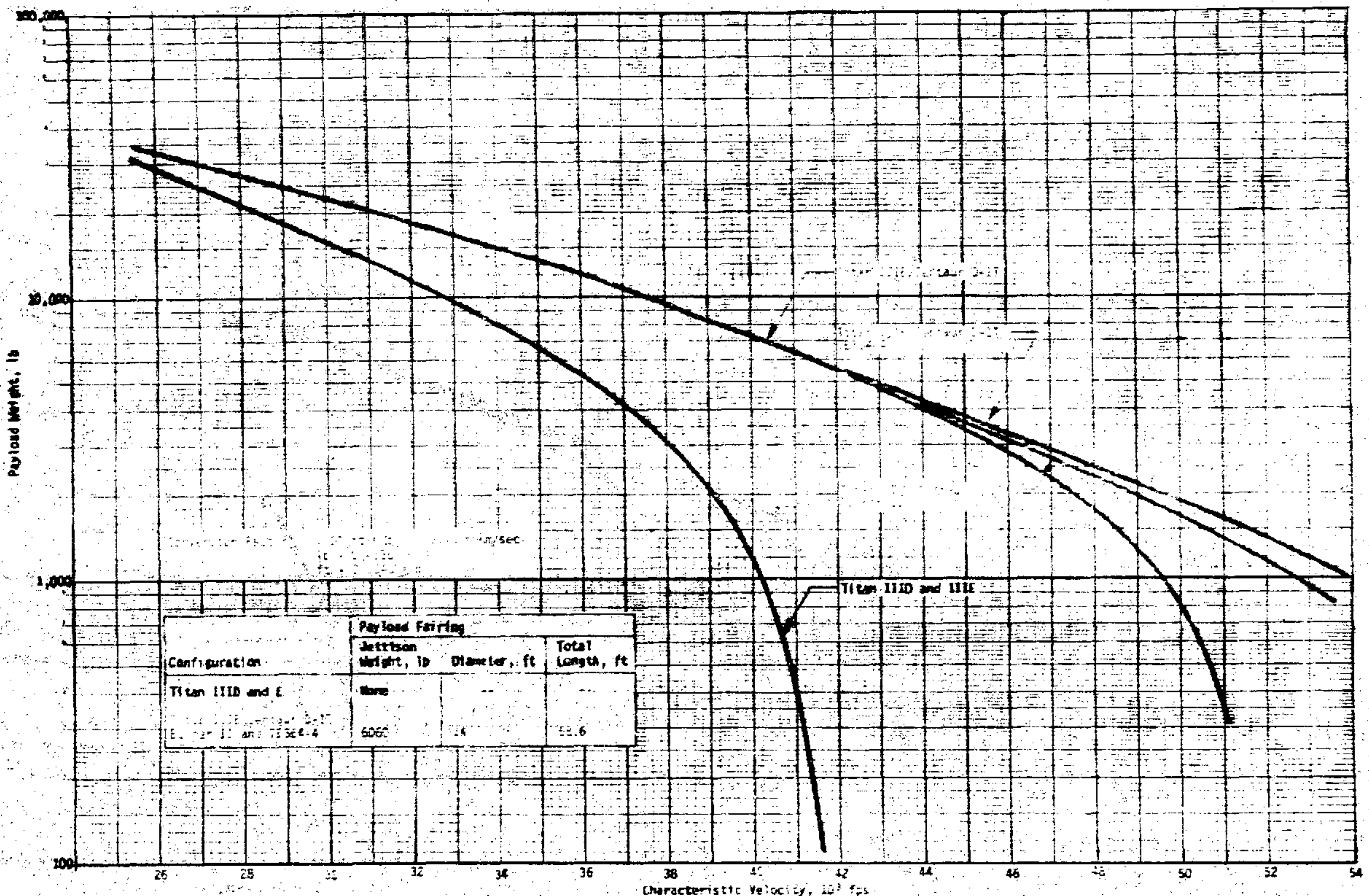


Fig. 2.6.3-2 Titan IIID and IIIE, Payload Weight vs Characteristic Velocity, ETR

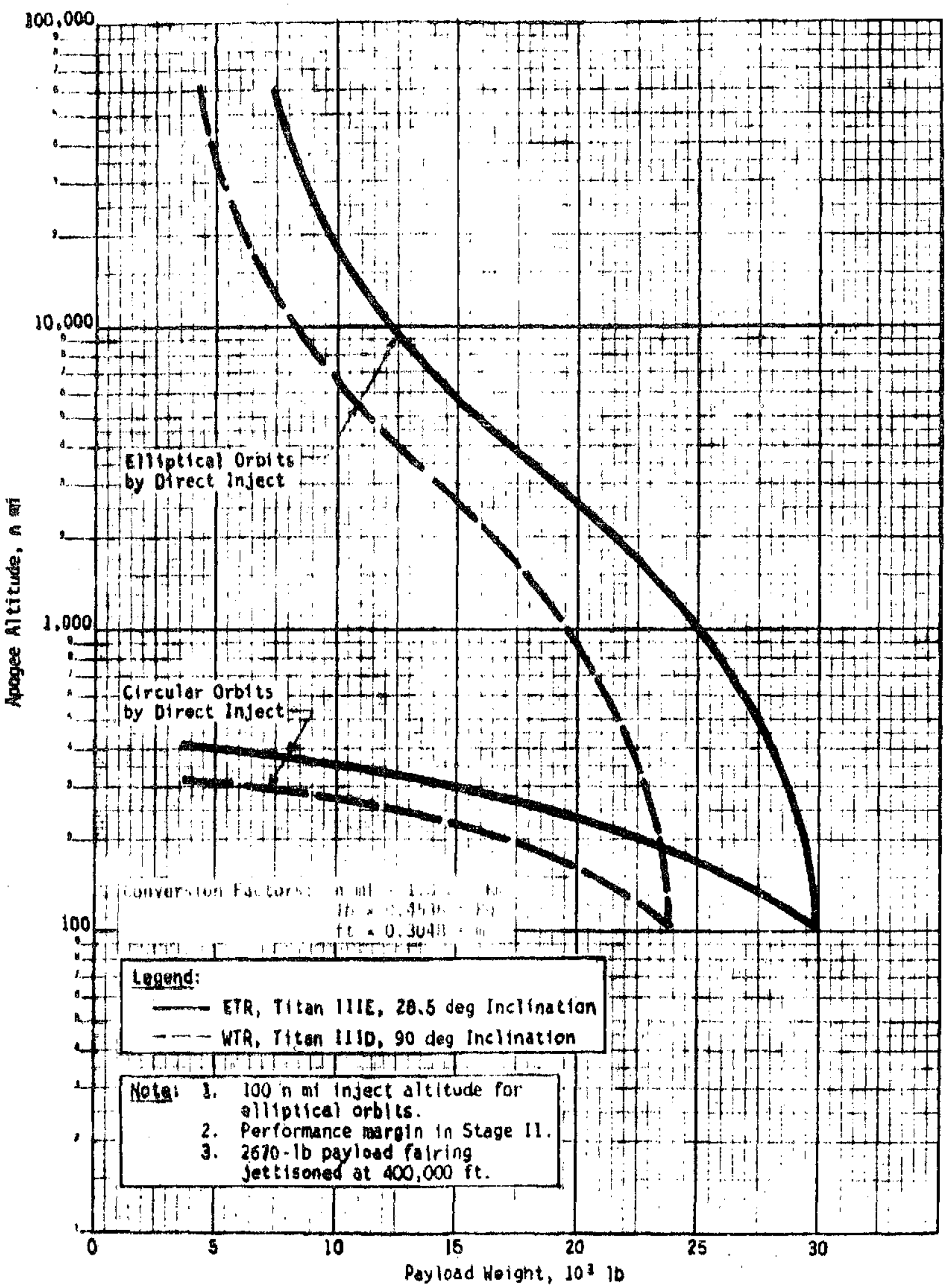


Fig. 2.6.3-3 Titan III Panel IIIE, Payload vs Altitude, ETR and WTR

SYSTEM REQUIREMENTS

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.1 SAFETY	GAC					
3.1.1 The EOS must be capable of providing a safe mission operation while passively contained within the Orbiter cargo bay and have provisions for relaying immediately to the Orbiter crew, while it is attached to Orbiter, any emergency conditions originating in the EOS.						●
3.1.2 While in the Orbiter cargo bay on the launch pad or during ascent, retrieval, re-entry and landing, the EOS shall provide a readout of parameters critical to Shuttle system and range safety operations.						●
3.1.3 As a goal, no single EOS failure shall result in a hazard which jeopardizes the flight or ground crews.						●
3.1.4 Appropriate safety factors shall be used where necessary to minimize the possibility of failures which might affect manned safety (i.e., structures, pressure vessels, etc.).						●
3.1.5 Manned factors of safety will be maintained under Shuttle abort load conditions						●
3.1.6 Provision for command override of critical EOS functions by the Orbiter crew shall be provided during stowage, deployment and retrieval operations.						●
3.1.7 EOS elements shall have self contained protective devices or provisions against EOS generated hazards while mounted to the Orbiter. Hazards generated by Orbiter-EOS interactions during load, transport, deploy and retrieval activities shall be identified and mutually resolved.						●
3.1.8 Provisions shall be provided for emergency manual release of EOS to Orbiter connections.						●

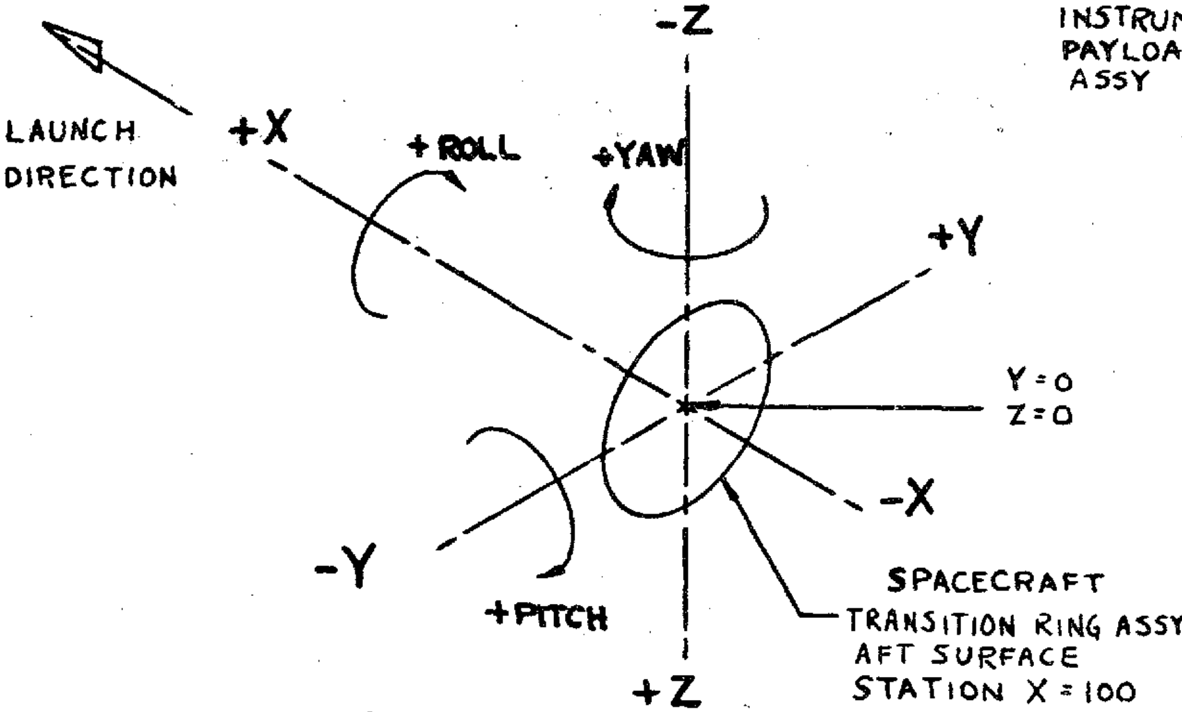
	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.1.9	A pressure relief capability shall be provided for the EOS tanks which automatically limits the maximum pressure. Venting shall be through the EOS/Orbiter interface when EOS is in the Orbiter payload bay.						●
3.1.10	No single failure shall result in unprogrammed motion of the EOS.						●
3.1.11	Provisions shall be provided for remote emergency jettisoning of EOS deployable equipment as necessary to complete retrieval and stowage operations.						●
3.1.12	RF communication capability shall be available between the Orbiter and the EOS for command and control functions.						●
3.1.13	The critical command and control circuitry shall be designed to be fail-operational/fail-safe as a minimum.						●
3.1.14	Safety design features such as interlocks, redundancy, grounding and isolation devices shall be incorporated so that no single detectable failure or combination of undetectable failures shall result in premature detonation of explosive devices.						●
3.1.15	Unused explosive devices aboard the EOS must be safed on command and safing verification sent to the Orbiter prior to retrieval.						●
3.1.16	Toxic or other chemically hazardous gases, liquids, or particles shall not be vented into the Orbiter payload compartment, and shall be isolated from the Orbiter environmental control system.						●
3.1.17	All pressurized tankage in the EOS will be vented to 20 psia after restow in the Orbiter.						●
3.1.18	All enclosed EOS volumes into which toxic or flammable vapors or liquid could enter must be purged or inerted with an inert gas and the volumes atmosphere sampled while the EOS is on the ground.						●

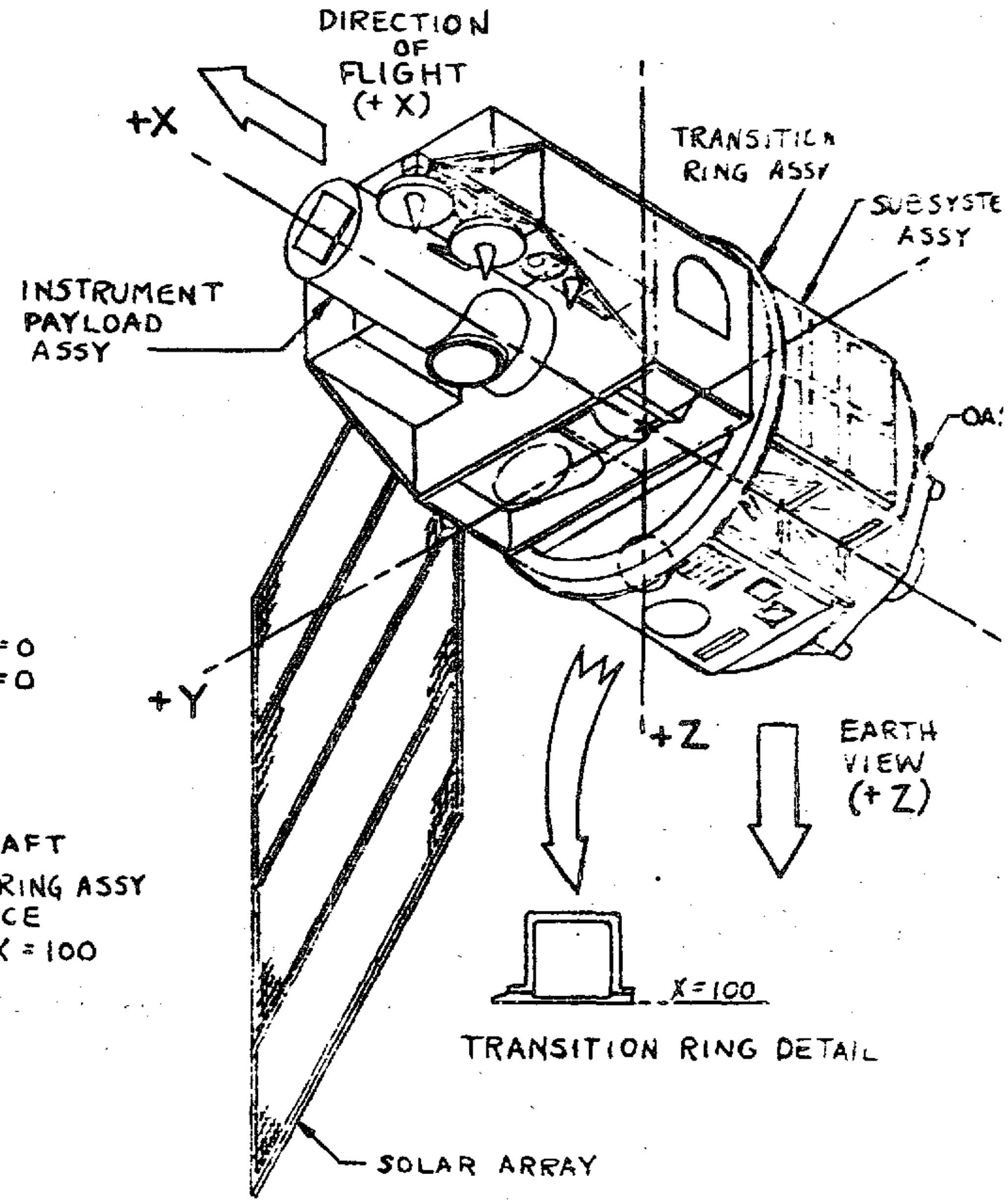
REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.1.19 Provide redundant valves on all lines which can become leak paths overboard.						●

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.2 RELIABILITY						
3.2.1 The mean mission duration shall be 2 years.	AA/ - 1	●	●	●	●	
3.2.2 Consumables and survival shall be 5 years	AA/ - 1	●	●	●	●	
3.2.3 After EOS refurbishment the S/C shall meet the original reliability goal.	GAC	●	●	●	●	●

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.3 MAINTAINABILITY						
3.3.1 EOS shall have the capability to be refurbished in space by the Shuttle Orbiter	A/1.3.6/1-5	●	●	●	●	●
3.3.2 The Shuttle Orbiter will retrieve the EOS for ground refurbishment	A/1.3.6/1-5	●	●	●	●	●

REQUIREMENT	SOURCE	OPTION				
		1	2	3	4	5
3.4 SPACECRAFT						
3.4.1 The basic EOS reference system shall be three orthogonal axes as defined in Fig. 3.4-1.	R/ - / -	●	●	●	●	●
3.4.2 The three basic subsystem modules: ACS, EPS, Comm. & Data Handling, shall be the same for all EOS configurations.	GAC	●	●	●	●	●





SPACECRAFT (S/S) COORDINATE REFERENCE SYSTEM

TABLE 3.4-1

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	B	C	D	E	F
3.5	Instruments												
3.5.1	Thematic Mapper (TM)	(TS 2.4)											
3.5.1.1	The TM images are normally beneath the EOS, but when required shall be available, upon command, from regions offset up to ± 45° from the down-nadir direction	A/2.1.1/2-1	●	●	●			●	●	●			
3.5.1.2	TM design parameters are given in Table 3.5-1	A/2.1.1/2-1	●	●	●								
3.5.2	High Resolution Pointable Imager (HRPI)	(TS 2.4)											
3.5.2.1	The HRPI images are normally beneath the EOS, but when required, upon command, shall be available from regions offset up to ± 30° from the down-nadir direction	B/ - /6		●	●								
3.5.2.2	HRPI design parameters are given in Table 3.5-1	A/2.1.1/2-1		●	●								
3.5.3	Synthetic Aperture Radar (SAR)												
3.5.3.1	SAR Parameters Frequency: Dual, X- and L- bands Swath: ≤ 40 Km Resolution: 30 meters	A/2.3.1/2-9	●								●		
3.5.3.2	SAR will be "on" for two 10-minute periods per orbit	B/ - /13	○								○		
3.5.4	Passive Multichannel Microwave Radiometer (PMMR) The orbit and scan parameters are contained in table 3.5-2.	AK/1.1.1/3	○								○		

TABLE 3.5-1

INTERIM DESIGN PARAMETERS FOR THE THEMATIC MAPPER (TM) AND THE HIGH RESOLUTION POINTABLE IMAGER (HRPI)

			THEMATIC MAPPER (TM)		HIGH RESOLUTION POINTABLE IMAGER (HRPI)	
BAND NO.	SPECTRAL REGION (μm)	ASSUMED RADIANCE, N_1 ($w\ m^{-2} sr^{-1}$)	IFOV (μrad) (approx.)	S/N(PP/RMS) (@N_1 &MTF=1)	IFOV (μrad) (approx.)	S/N(PP/RMS) (@N_1 &MTF=1)
* 1	0.5 - 0.6	2.2	35	10	10	6
* 2	0.6 - 0.7	1.9	35	7	10	6
* 3	0.7 - 0.8	1.6	35	5	10	6
* 4	0.8 - 1.1	3.0	35	5	10	6
5	1.55 - 1.75	0.8	35	5	-	-
6	2.1 - 2.35	0.3	35	5	-	-
7	10.4 - 12.6	20.0 @ 300K	140	0.5K NEΔT @ 300K	-	-

*Spectral Bandwidth may be reduced

TABLE 3.5-2

System Specifications and Assumptions

A. Orbit and Scan Specifications	
Orbit Height	1,000 km
Nadir Angle	Approx. 40° (Assume 45°)
Incidence Angle	50° ± 2° (52.2° for 45° nadir angle)
Scan Mode	Conical
Scan Angle	±35°
B. Frequencies and IFOV Specs	
Frequency, GHz:	4.99 10.69 18.0 21.5 37.0
IFOV, km:	178 88 88 88 22
C. Antenna Specs	
Main Beam Efficiency	≥80%
Maximum Sidelobes:	
In Scan	<15 dB
Cross Scan	<25 dB
Cross Polarization Isolation	>25 dB
D. Bandwidth and Temperature Specs	
RF Bandwidth	>240 MHz (all frequencies)
Temperature Sensitivity	<0.3° at 4.99 GHz
	≤1.0° at other frequencies
Target Temperature	300°K ± 10°K
Dynamic Range	10°K to 330°K
Absolute Accuracy	2°K

TABLE 3.5-2 Continued

E. Assumptions

Antenna	Single dish with multiple feeds
Scan Mode	Zig-zag in azimuth (+35° to -35° and back)
Scan Speed	Sinusoidal (60% efficiency relative to linear scan)
Receivers	Dicke, with square wave modulation (b=2). Two receivers at 37 GHz (one for each polarization); one receiver for both polarizations at each of the other frequencies
Sensing	Vertical polarization for one-half scan period, horizontal for other half
Coverage	Contiguous for 37 GHz; overlap allowed for other frequencies
Temperatures	T_a = 300°K, T_o = 290°K
Losses	L_a = 1.2 dB

REQUIREMENT	SOURCE	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5
3.6 DATA COLLECTION SYSTEM (DCS)						
3.6.1 The characteristics of the earth-based DCS platforms are contained in Table 3.6.1 and Figs. 3.6-1 and -2.	H/Table 4.4/4.19	○	○	○	○	
3.6.2 The DCS shall operate in the VHF RF range	G/3.2.1.3/3-13	●	●	●	●	
3.6.3 The DCS shall be compatible with an experiment density of at least 200 earth-based platforms within a 200 n.mi. (370 .4Km) diameter circle.	G/3.2.1.3/3-13	○	○	○	○	
3.6.4 The DCS electronic characteristics are: Volume 12,000 cc Weight 20 kg Power 40 watts	AD/-/2	○	○	○	○	
3.6.5 The DCS antenna characteristics are: Volume 42,000 cc Weight 4 kg Fig. 3.6-3 contains a sketch of the antenna	AD/-/2,3, & 4	○	○	○	○	
3.6.6 DCS commands are: Power 4 (2 on/off) Impulse 10	AD/-/2	○	○	○	○	
3.6.7 DCS telemetry: Analog 12 Bilevel 10	AD/-/2	○	○	○	○	

TABLE 3.6-1 (CONT)

• Time Frame:	
– Time of Implementation	1974 thru 1980
– Duration of Operation	Variable, 3 months to indefinite
• Data Dissemination	
– DCP Data Delay	Variable within two classes: > 24 hours, < 24 hours
– Position Location Data Delay	1 to 24 hours

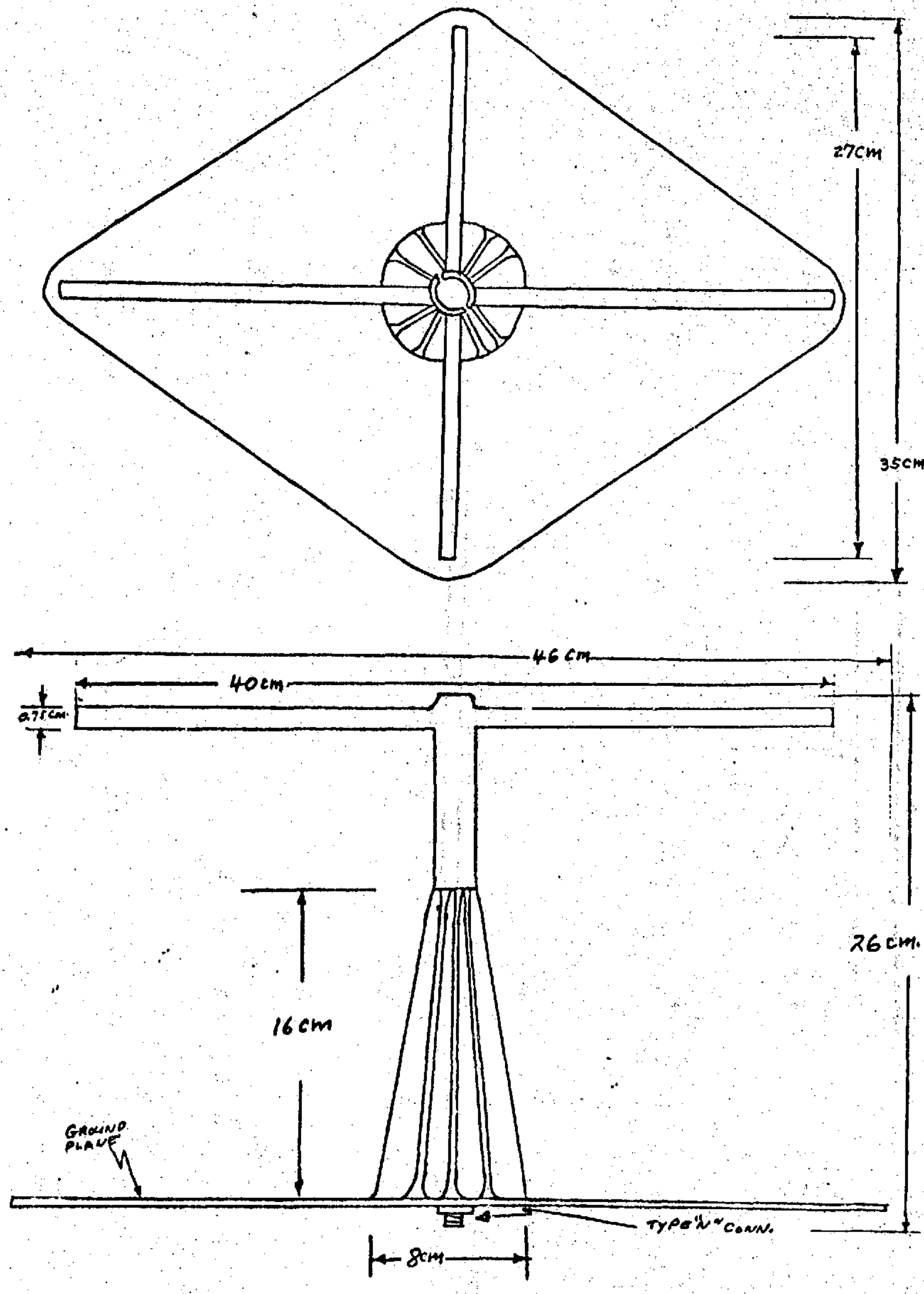


Fig. 3.6-3 DCS Antenna

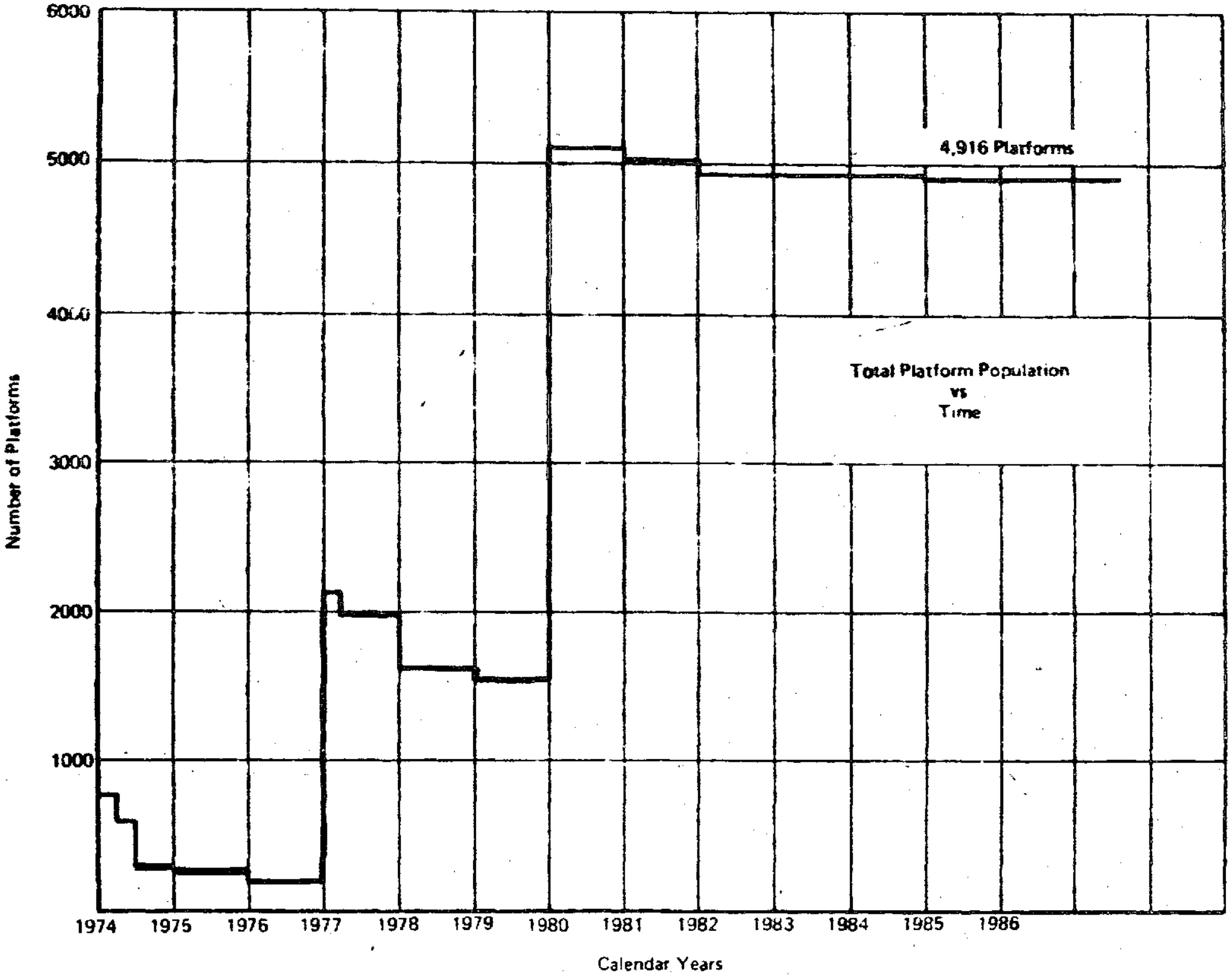


FIGURE 3.6-1 TOTAL DATA COLLECTION PLATFORM POPULATION VS TIME

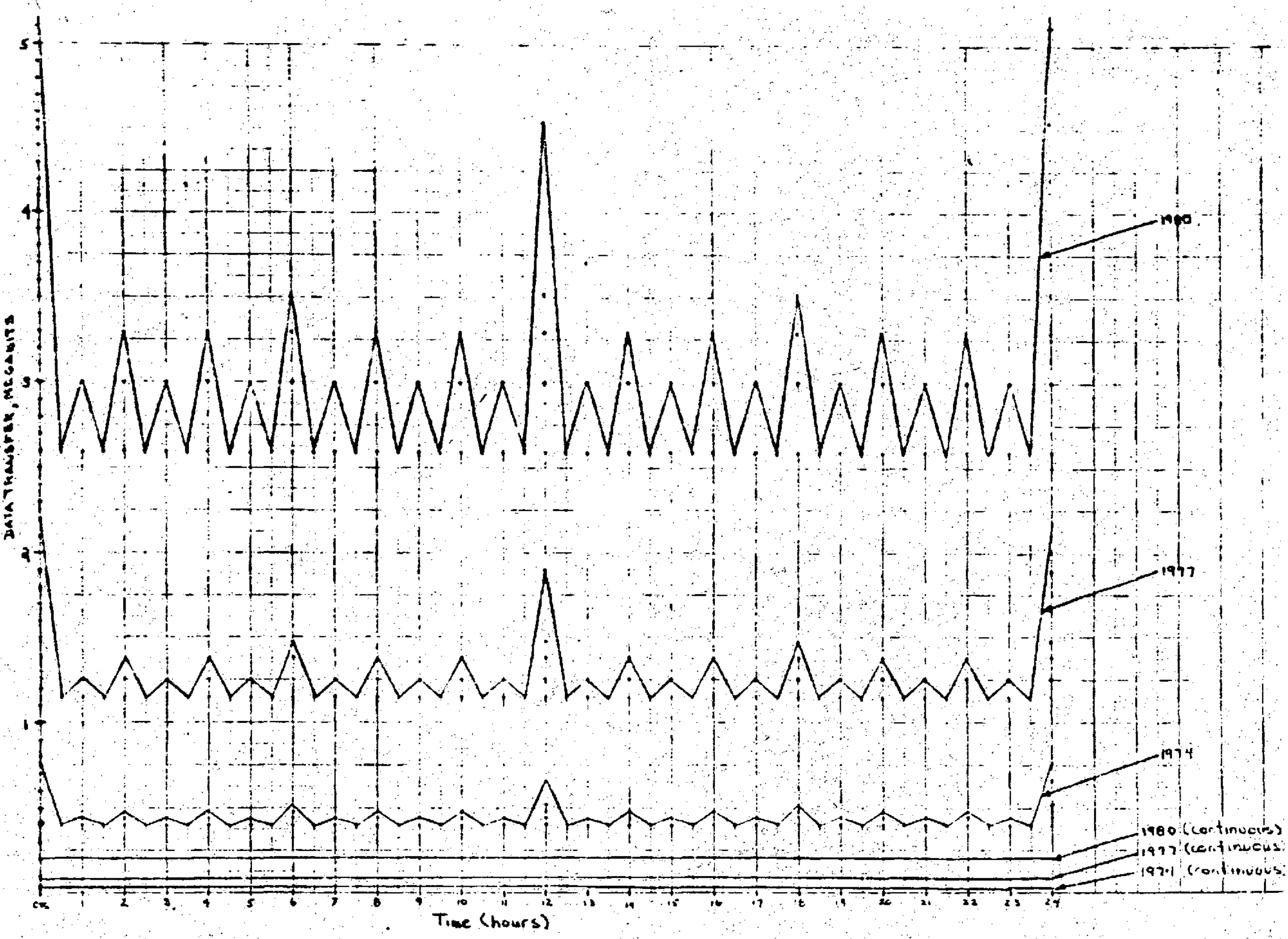


FIGURE 3.6-2 SATELLITE THROUGHPUT

REQUIREMENT	SOURCE	OPTION				
		1	2	3	4	5
3.8 SHUTTLE RESUPPLY PROJECT						
3.8.1 On orbit Shuttle resupply shall utilize the Special Purpose Manipulator provided by the Canadian Government	A/1.5.4/1-7	O	O	O	r	

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.9 S/C-TO-INSTRUMENT INTERFACES						
3.9.1 Thematic Mapper (TM)		o	o	o		
3.9.1.1 Communications and Data Handling						
3.9.1.1.1 The EOS shall provide for transmission of instrument sensor data to be selected from the following candidate rates: a. 50.8 Mbps b. 73.2 Mbps c. 88.9 Mbps d. 100 Mbps e. 102.5 Mbps f. 118.3 Mbps	X/ - / - (TS 4)					
3.9.1.1.2 The EOS shall provide for transmission of instrument status and health data in real-time and stored/playback modes: a. Digital <u>TBD</u> b. Analog <u>TBD</u>	X/ - / - (TS 4)					
3.9.1.1.3 The EOS shall provide timing signal clock pulses accurate to 10^{-5} sec to the instrument.	X/ - / - (TS 4)					
3.9.1.1.4 The EOS shall provide for relay from the ground to the instrument of 16 digital (On/Off) commands Logic 1 = + 3.5 VDC to + 5.5 VDC Logic 0 = 0 $\pm$ 0.5 VDC	X/ - / - (TS 4)					

REQUIREMENT	SOURCE	OPTION 1 2 3 4 5
3.9.1.2 Electrical Power		
3.9.1.2.1 The EOS shall provide 28 $\pm$ 7 VDC electrical power at levels of: a. Full operation 50 watts b. Dark side $\leq$ 50 watts	X/ - / - (TS 4)	
3.9.1.3 Attitude Control <u>TBD</u>		
3.9.1.4 Structure/Mechanical		
3.9.1.4.1 The EOS shall accommodate an instrument weight of 350 lb.	X/- / - (TS 4)	
3.9.1.4.2 The EOS shall provide a clear volume to accommodate an instrument configured as shown in Fig. 3.9.1-1	X/- / - (TS 4)	
3.9.1.4.3 The instrument shall be aligned relative to structural and ACS references to $\pm$ 0.1 mrad.	X/ - / - (TS 4)	
3.9.1.5 Thermal		
3.9.1.5.1 The EOS shall be compatible with an instrument total heat dissipation rate of 130 watts continuous.	X/- / - (TS 4)	
3.9.1.5.2 The EOS shall provide thermal insulation to isolate the instrument from the spacecraft, including insulating barriers in attachment hardware.	X/- / - (TS 4)	

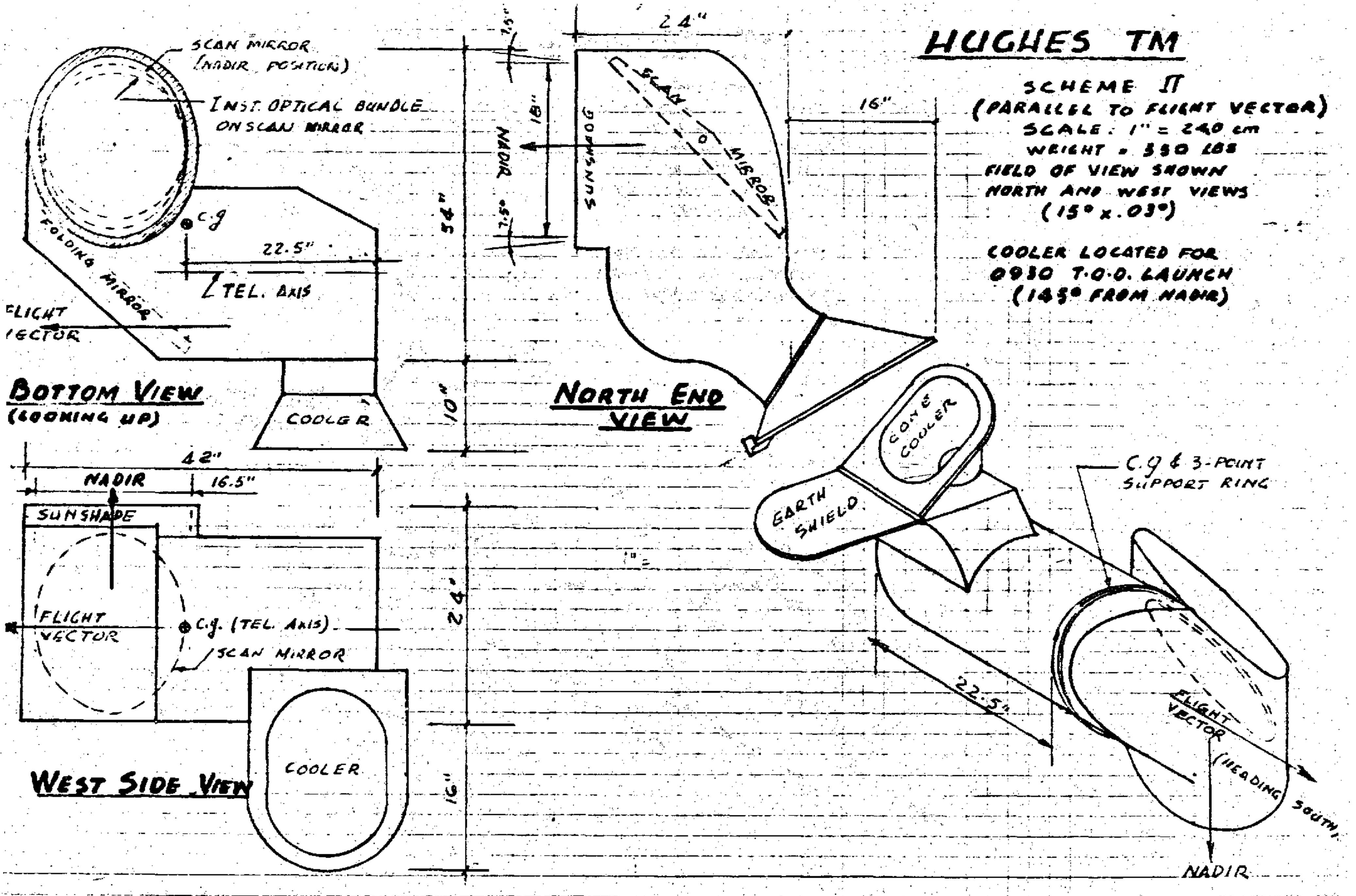


FIGURE 3.9.1-1 CANDIDATE TM CONFIGURATION

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.9.2 High Resolution Pointing Imager (HRPI)						
3.9.2.1 Communications and Data Handling						
3.9.2.1.1 The EOS data interface shall be compatible with High Speed Multiplexing	Y/ D/ 1.2 (TS 4)	●	●			
3.9.2.2 Electrical Power						
3.9.2.2.1 The EOS shall provide 28 ± 7 VDC electrical power at an average level of 100 watts, not including heaters.	Y/ D/ 1-2 (TS 4)	○	○			
3.9.2.3 Attitude Control TBD						
3.9.2.4 Structure/Mechanical						
3.9.2.4.1 The EOS shall accommodate an instrument weight of 600 lb	Y/ D/1-2 (TS 4)	○	○			
3.9.2.4.2 The EOS shall provide a clear volume to accommodate an instrument of: Diameter = 36 in Length = 84 in	Y/ D/ 1-2 (TS 4)	○	○			
3.9.2.4.3 The instrument shall be mounted to the spacecraft via 4 lugs located 42 inches up from the base of the HRPI.	Y/ D/ 1-2 (TS 4)	○	○			

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.9.2.5 Thermal						
3.9.2.5.1 The instrument shall be insulated from the Spacecraft	Y/ D/ 1-2 (TS 4)	●	●			
3.9.2.5.2 Heat leaks to the spacecraft through insulating blankets and mounts shall be less than 10 watts (as a goal)	Y/ D/ 1-2 (TS 4)	○	○			

REQUIREMENT	SOURCE	1	2	3	4	5	A	B	C	D	E	F
3.9.3 Synthetic Aperture Radar (SAR) Currently, two alternate SAR configurations are under consideration. Where requirements differ between configurations, both are identified.												
3.9.3.1 Communications and Data Handling												
3.9.3.1.1 The EOS shall provide for transmission of instrument data in real-time at a rate of 170 Mbps	Z/5.1.2/5-7	O								O		
3.9.3.2 Electrical Power												
3.9.3.2.1 The EOS shall provide <u>TBD</u> V electrical power to the instrument at: a. Configuration 1 - 1140 watts b. Configuration 2 - 1250 watts	Z/Table 3.1.2-1/ 3-7											
3.9.3.3 Attitude Control												
3.9.3.3.1 The EOS shall provide attitude control to the following limits for a period of 10 min/orbit Pointing / Stability Error Pitch, Yaw: 0.02 deg / 0.01 deg/sec Roll: 0.06 deg / f (f)	Z/Table 3.2.3.7-1/ 3-95	O								O		
3.9.3.4 Structure/Mechanical												
3.9.3.4.1 The EOS shall accommodate an instrument electronics package of the following characteristics: Config. 1 / Config. 2 Dimensions: 31 x 22 x 9.5 in / 38 x 24.5 x 9.5 in Weight: 172 lb / 213.5 lb	Z/Table 4.3.1-1/ 4-3	O								O		

REQUIREMENT			SOURCE	OPTION										
				1	2	3	4	5	A	B	C	D	E	F
3.9.3.4.2 The EOS shall make provisions for a side mounted radar antenna of the following characteristics:				o								o		
	Config. 1	Config. 2												
Dimensions	13.5 x 2.5 x 1 ft	27 x 2.5 x 1 ft	Z/Table 3.1.2-1/ 3-7											
Weight	92 lb	174 lb	Z/Table 4.3.1-1/ 4.3											

REQUIREMENT	SOURCE	OPTION
3.9.4 Passive Multichannel Microwave Radiometer (PMMR)	K/3.5.2.5/3-128	1 2 3 4 5 A BC DE FG

The radiometers have the 80 cm scanning reflector and a set of four 7 cm diameter cold horns mounted on the spacecraft structure to view the earth (reflector) and cold space (horns) respectively. The reflector can be positioned to look in front or behind the spacecraft nadir. It scans symmetrically about this track $\pm 35^{o}$. The antennas are mounted so their field of view does not intersect the spacecraft or any solar panels or experiments. The antenna itself must not obstruct the solar paddles or any horizon scanners.

The four cold horns are pointed to avoid looking at the sun if possible. Sun temperature corrections can be made, but these corrections require additional data processing.

The radiometer receivers can be packaged into a volume of 0.06 m^3 with the cold horns and antenna feeds mounted external to the spacecraft interior.

Table 3.9.4-1 shows the power and weight estimates for the passive facility excluding only the 13.9-GHz radiometer presently integrated into the active facility.

TABLE 3.9.4-1

RECEIVER POWER AND WEIGHT

	Power (W)	Weight (kg)
53-GHz channel	5.0	2.268
36-GHz channel	8.0	7.2576
22-GHz channel	5.0	3.6288
18-GHz channel	5.0	3.6288
5-GHz channel	5.0	3.6288
Power supply (loss)	12.0	4.5360
Feed system	-	0.9072
Cold horn/radiation	-	0.9072
TM data system	5.0	-
	43.0	26.7624

Total System Weight and Power

Receivers	45W	26.8 kg
Antenna Reflector	-	3.0 kg
Antenna Drive and Support Structure	18W	6.8 kg
Cabling and Thermal	-	2.27 kg
	63.0W	38.8 kg

Note: The 13.9-GHz radiometer's power and weight are included as part of the active sensor power and weight.

REQUIREMENT		SOURCE	OPTION 1 2 3 4 5
3.11	S/C-TO-SHUTTLE INTERFACES	(TS 3)	
3.11.1	Communications and Data Handling		
3.11.1.1	While the EOS is attached to Orbiter, the Orbiter will support EOS telemetry as follows: a. Up to 25 Kbps of EOS/Instrument status data (hardline) to be interleaved with Orbiter operational telemetry. b. Up to 256 Kbps of EOS/Instrument data to be relayed to the ground via wideband FM transmitter.	AC/5.3.2.2d/ 5-5	
3.11.1.2	After EOS release from the Orbiter, the Orbiter will accept up to 16 Kbps EOS/Instrument telemetryhaving the following characteristics: o S-band, phase modulation o Frequency band, 2200 - 2300 MHz	AC/5.3.2.2e/5-5	
3.11.1.3	While the EOS is attached to the Orbiter, the Orbiter will provide to the EOS a 2.4 Kbps hardline command channel, of which 0.4 Kbps is allocated to vehicle and subsystem overhead.	AC/5.3.2.3c/5-6	

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
3.11.1.4	After EOS release from the Orbiter, the Orbiter will be capable of generating and transmitting to the EOS 2.4 Kbps of command data, of which 0.4 Kbps is allocated to vehicle and subsystem overhead, with the following characteristics: o S-band, phase modulation o Frequency band, 2025-2120 MHz o Time division multiplex (TDM) serial data of 8 Kbps consisting of encoded command data and synchronization.	AC/5.3.2.3d/ 5-6					●
3.11.1.5	The EOS shall provide commutation and subcarrier oscillators compatible with the Orbiter wideband transmitter for television and wideband experiment data. For digital data, the EOS shall perform the required encoding at a bit rate compatible with the capabilities of the Orbiter wideband transmitter.	AC/5.3.2.5/ 5-7					●
3.11.1.6	Orbiter will provide both RF and hardline (umbilical) interfaces between the Orbiter communications subsystem and launch facilities for prelaunch telemetry, commands, TV, and wideband data.	AC/5.3.2.6/ 5-7					●

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.11.2 Electrical Power						
3.11.2.1 During ascent and descent Orbiter will provide electrical power to EOS/Instruments as follows: o 1 Kw average o 1.5 Kw peak	AC/6.0/6-1					●
3.11.2.2 During orbital operations Orbiter will provide electrical power to EOS/Instruments as follows: o 5 Kw average o 8 Kw peak	AC/5.0/6.1					●
3.11.2.3 Orbiter will provide total electrical energy to EOS/Instruments of 50 Kwh.	AC/6.0/6.1					●
3.11.2.4 Additional energy requirements of EOS/Instruments may be provided with the necessary additional consumables, tankage, and plumbing chargeable to EOS/Instrument weight.	AC/6.0/6.1					●
3.11.2.5 The electrical power characteristics at the EOS/Instruments - Orbiter interface is as follows: o Power: 28VDC nominal, two wire, structure ground (payload must not use structure for DC return) o Steady-state limits: 23-32.0 VDC intermittent duty 24-32.0 VDC continuous duty o Ripple voltage: 1V peak-to-peak	AC/6.0/6.1					●

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
3.11.3	Attitude Control						
3.11.3.1	EOS shall provide data to the Orbiter for attitude control requirements prior to separation from Orbiter.	AC/3.3.2/3-5					●
3.11.3.2	The Orbiter will maintain attitude to $\pm$ 0.1 degrees.	AC/3.3.2/3-5					●

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.11.4 Structural/Mechanical						
3.11.4.1 The EOS/Instrument shall fit within a maximum dynamic envelope of 15 ft diam by 60 ft length	AC/4.1/4-1					●
3.11.4.2 The EOS shall structurally interface with the Orbiter via the standard attachments defined in Fig. 3.11.4-1	AC/4.2/4-1					●
3.11.4.3 Orbiter payload c.g. shall fall within the envelope defined in Figs. 3.11.4-2 through -4	AC/4.2/4-2					●
3.11.4.4 The Orbiter will induce random vibration levels within the payload bay as shown in Fig. 3.11.4-5, not including payload impedence effects	AC/10.1/10-1					●
3.11.4.5 The acoustic environment within the Orbiter payload bay is defined in Figs. 3.11.4-6 and -7	AC/10.2/10-1					●
3.11.4.6 The pressure environment within the Orbiter payload bay during ascent-to-orbit is defined in Fig. 3.11.4-8	AC/10.4/10-1					●
3.11.4.7 The deployment and retrieval of EOS is accomplished by the general purpose remote manipulator system (RMS). Table 3.11.4-1 lists some basic characteristics of the RMS. One manipulator arm is provided by the orbiter and may be mounted on either left or right longeron. If a second manipulator is required, the weight is chargeable to the payload. The manipulator has a maximum reach of 52 ft. (Ref. Fig. 3.11.4-9). 7	AC/4.3/4-2					●

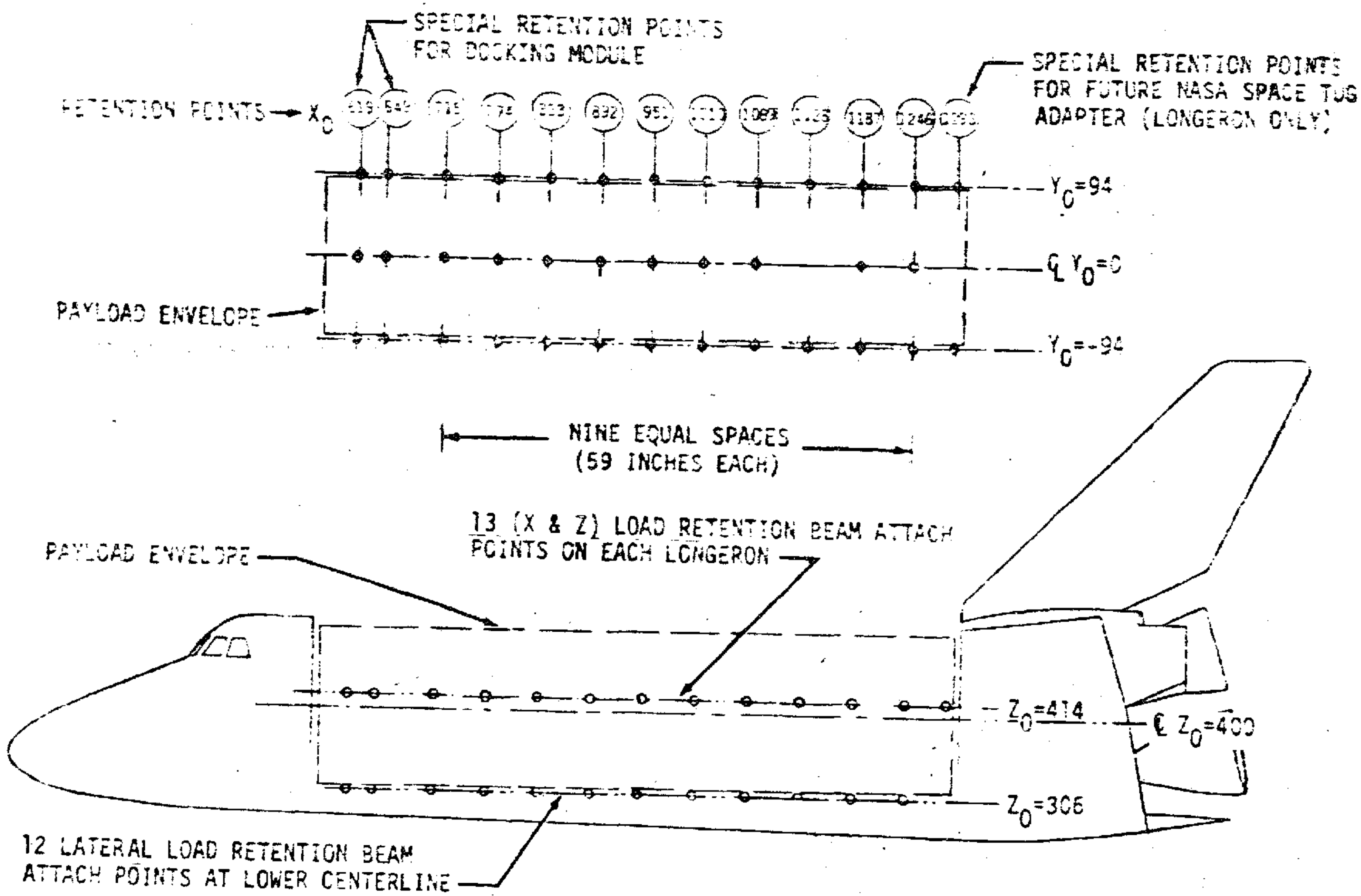


Fig 3.11.4 - 1 - PAYLOAD ATTACHMENT LOCATIONS

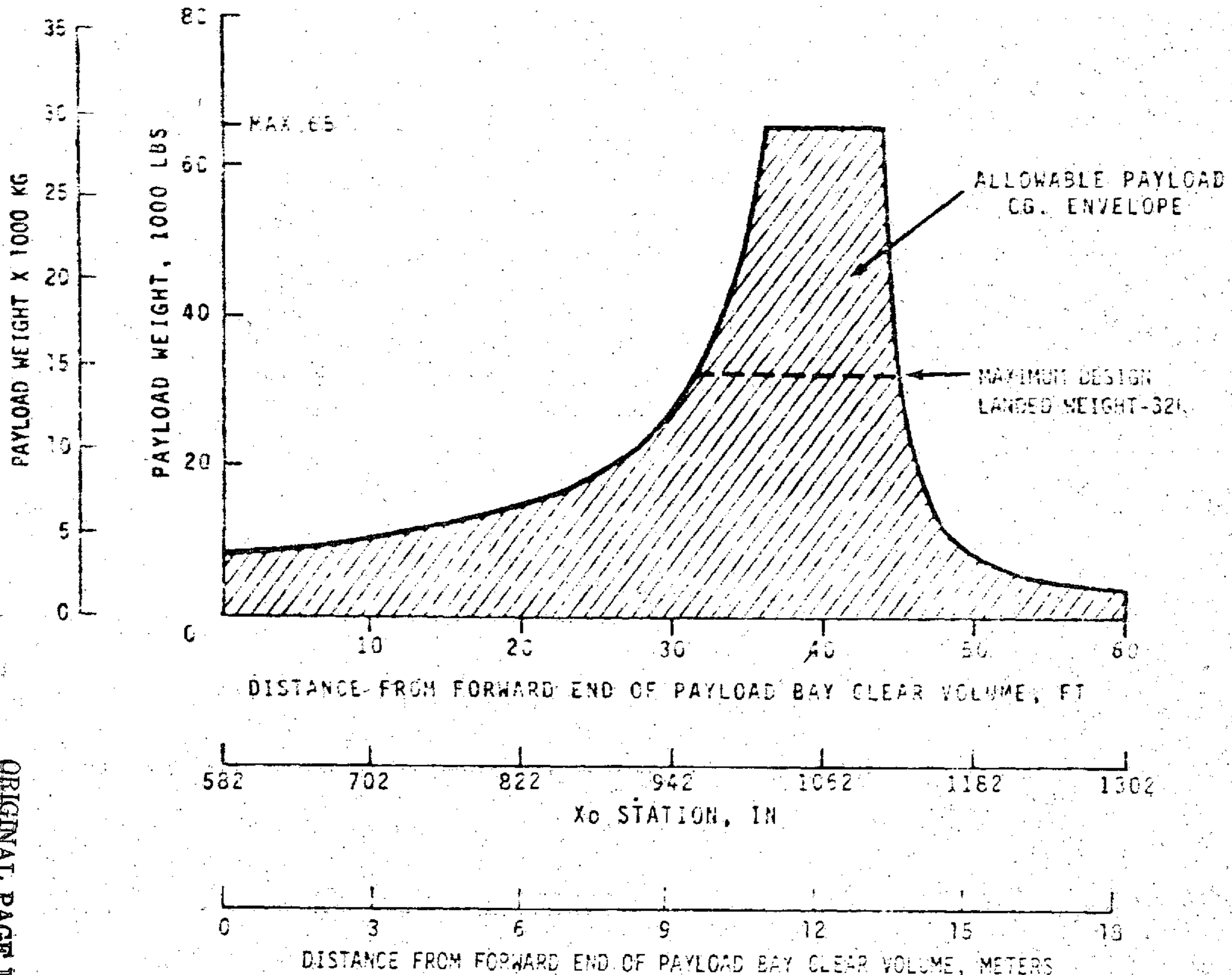


Fig 3.11.4 - 2 PAYLOAD LONGITUDINAL C.G. ENVELOPE

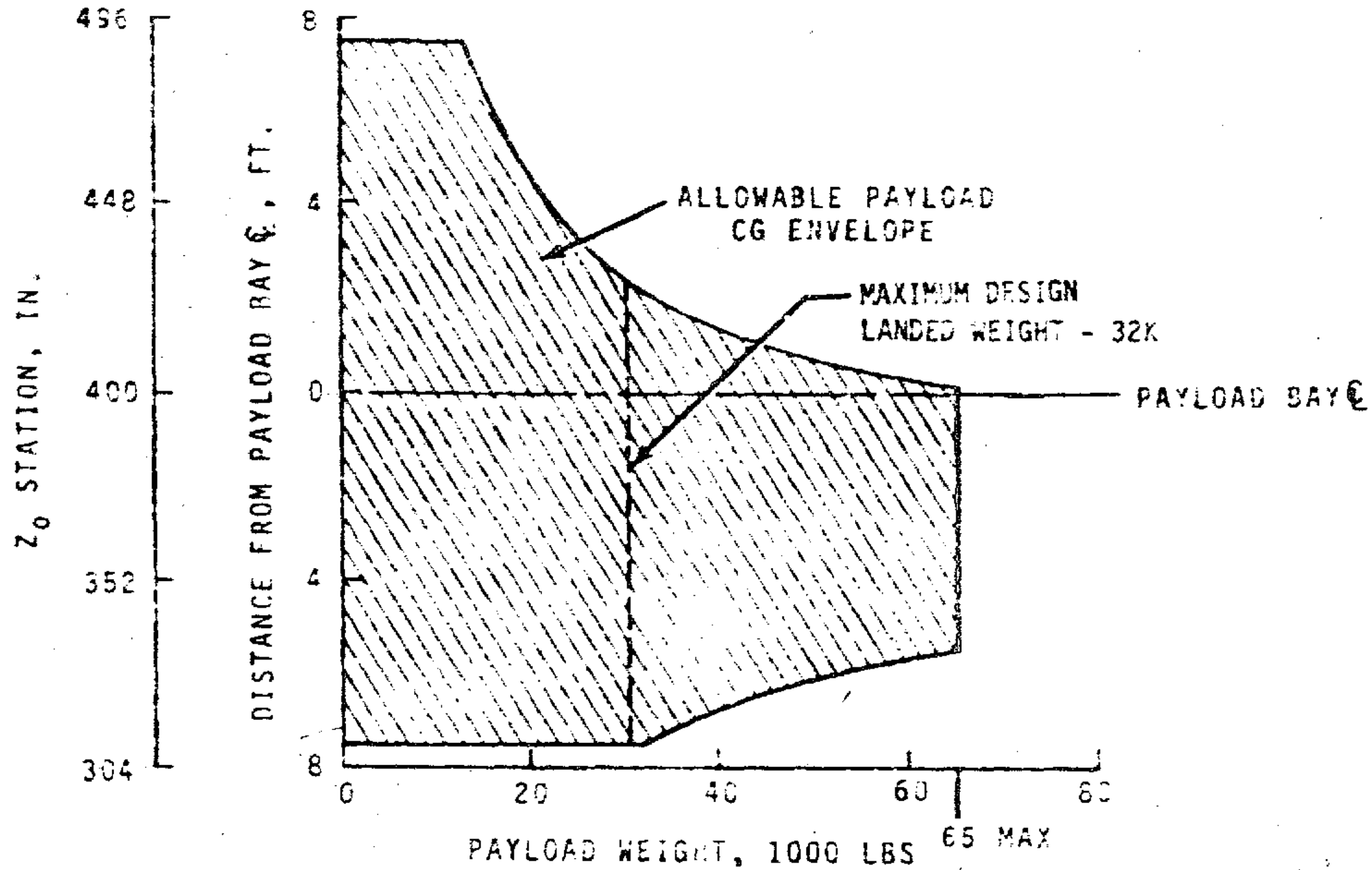


Fig 3.11.4 - 3 -PAYLOAD VERTICAL CG ENVELOPE

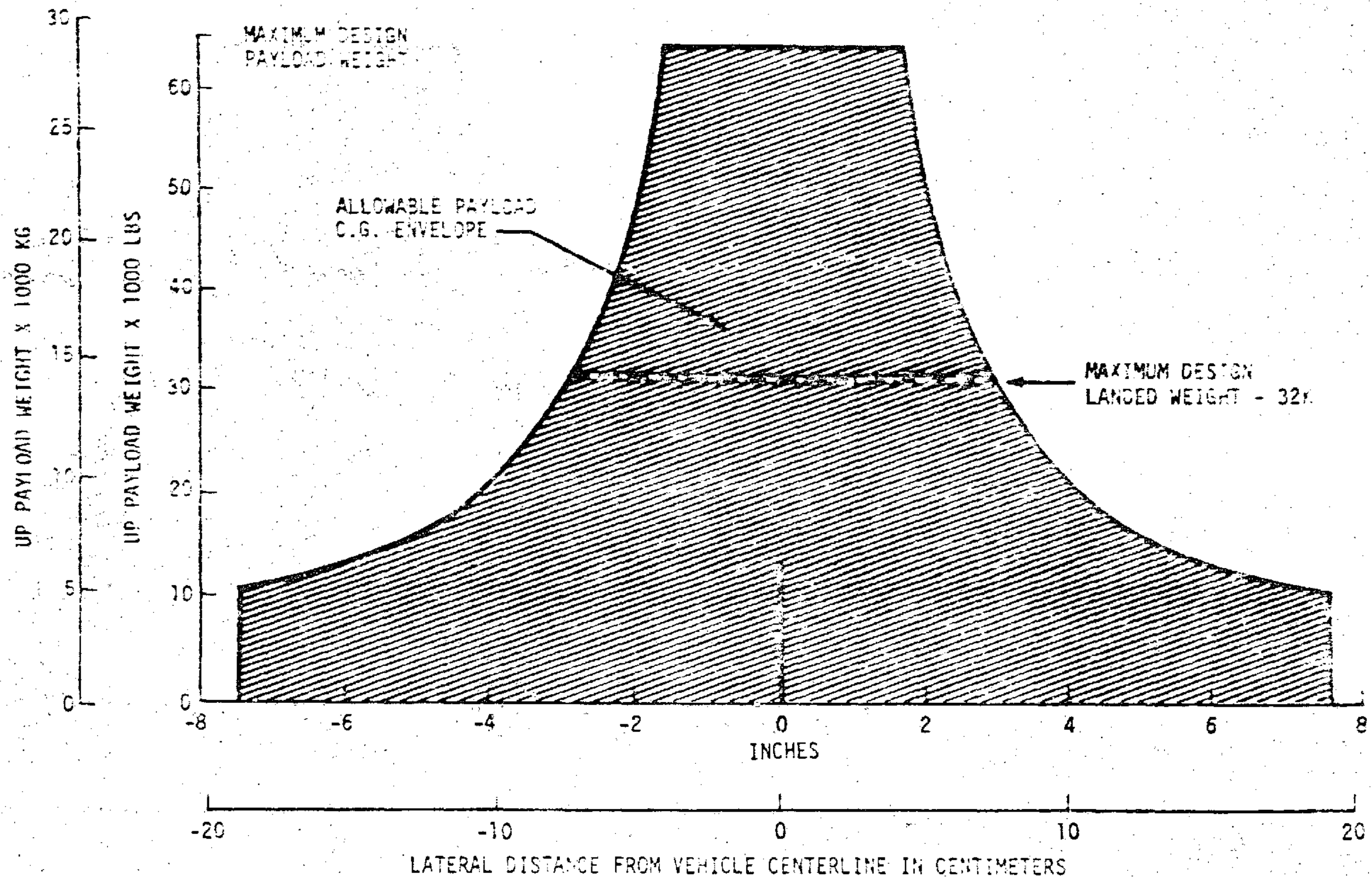


Fig 3.11.4-4 PAYLOAD LATERAL C.G. ENVELOPE

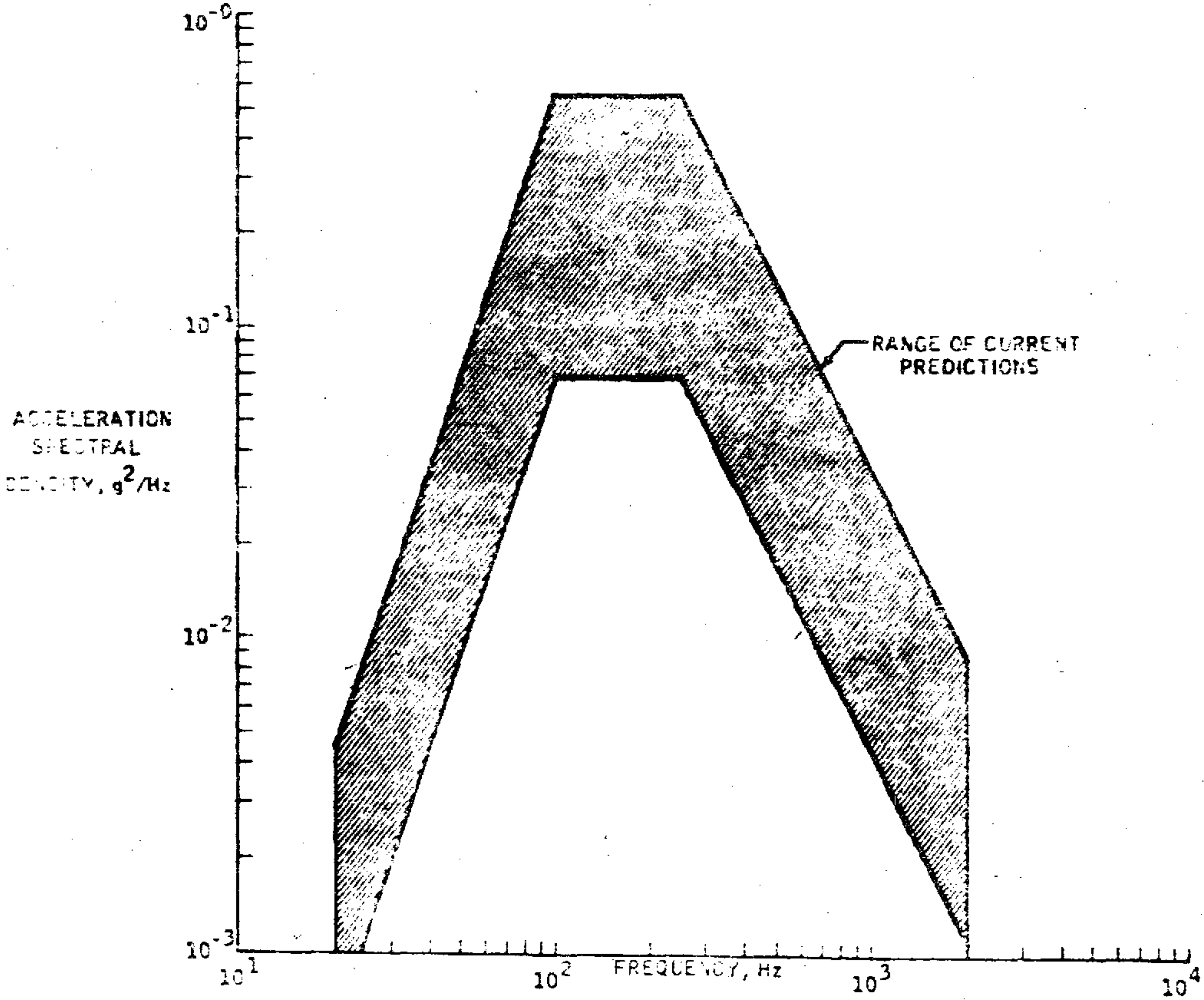


Fig 3.11.4-5 - ANALYTICAL PREDICTIONS OF THE ORBITER MID-FUSELAGE PRIMARY STRUCTURE VIBRATION SPECTRA

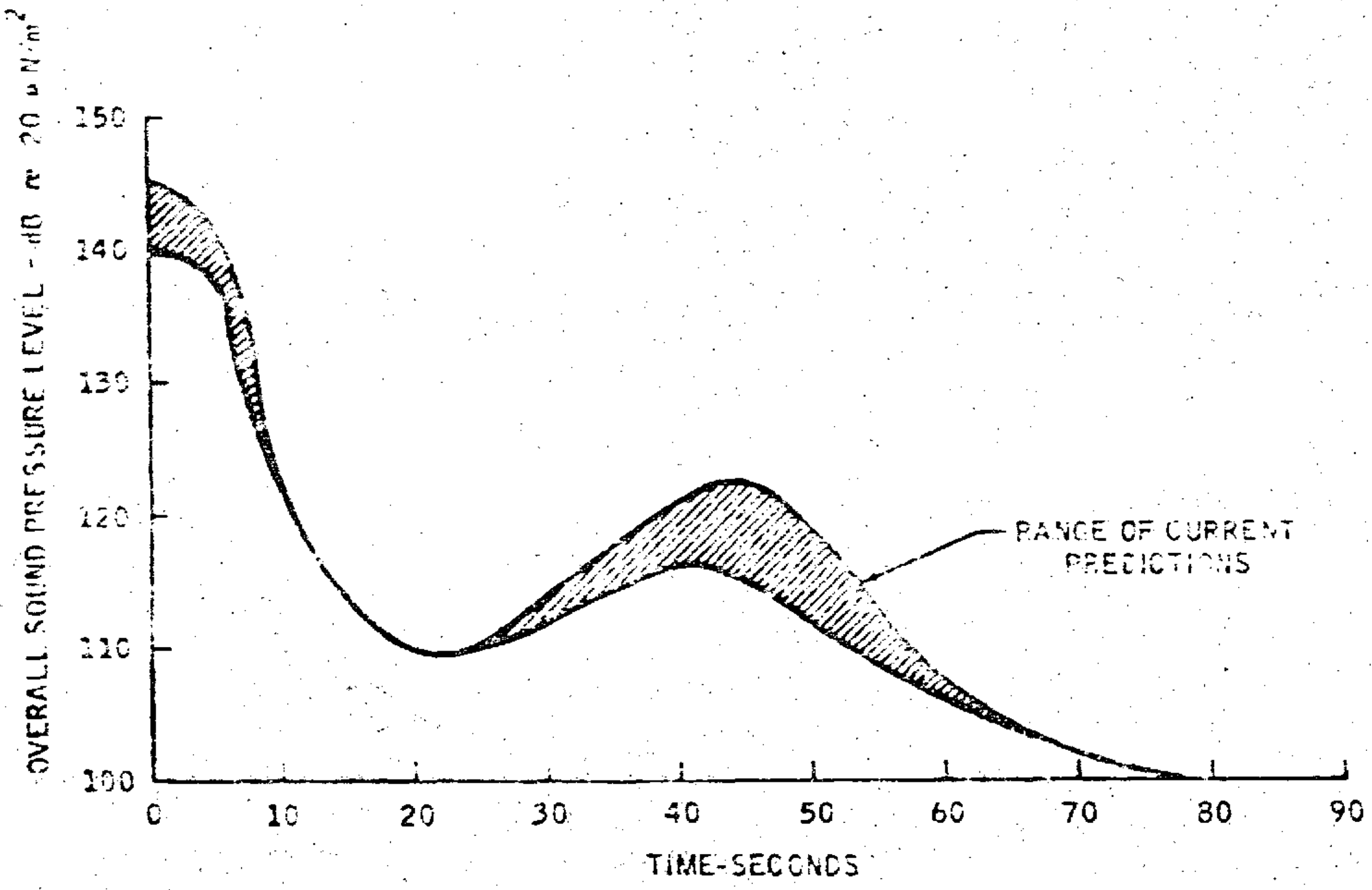


Fig 3.11.4-6 - ANALYTICAL PREDICTIONS OF THE ORBITER PAYLOAD BAY INTERNAL ACOUSTIC ENVIRONMENT

ORIGINAL PAGE IS OF POOR QUALITY

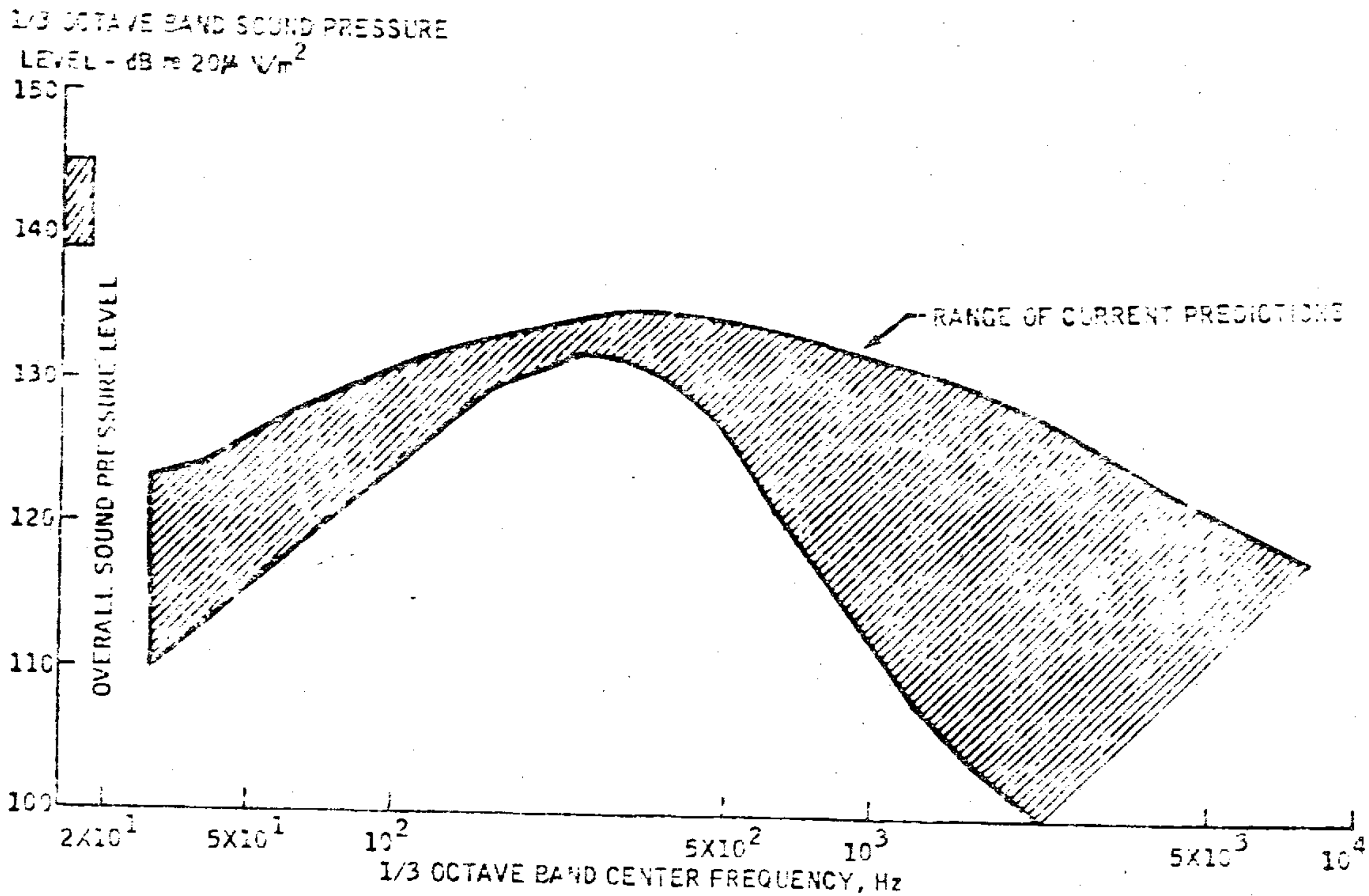
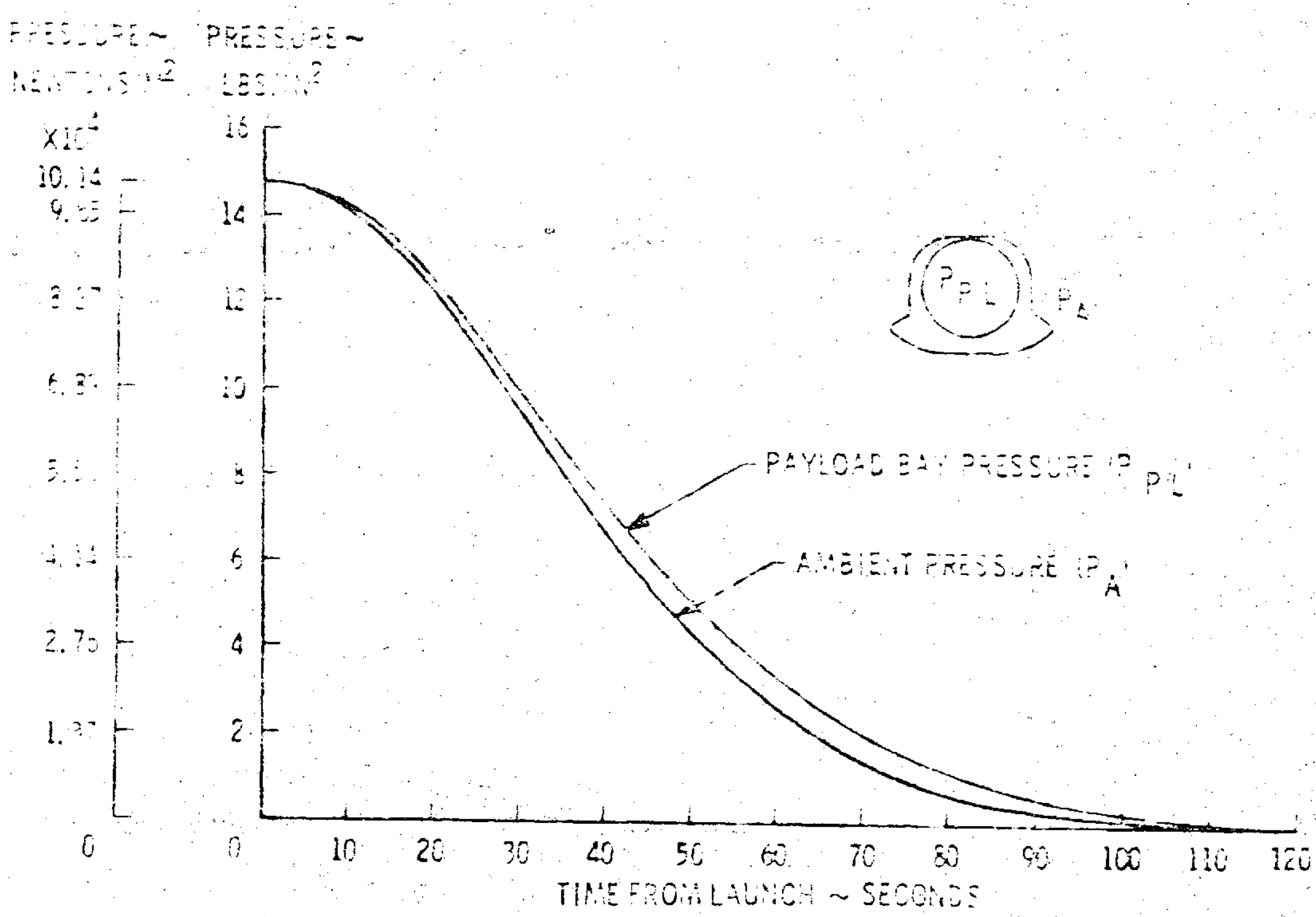


Fig 3.11.4-7 ANALYTICAL PREDICTIONS OF THE ORBITER PAYLOAD BAY INTERNAL ACOUSTIC SPECTRA



ORIGINAL PAGE IS OF POOR QUALITY

FIG. 3.11.4-8 - PAYLOAD BAY ASCENT PRESSURE HISTORY

Operational Mode	RMS Characteristics
Payload deployment	32K payload in less than 7 minutes
	65K payload in less than 10 minutes
	Residual rates 1.0 - 2.0 fps and 0.15 deg/sec
	Up to 5 payloads/mission
Payload retrieval	Stabilized payloads up to 65K
	Stopping distance:
	65K payload -- 2.5 feet at a tip speed of 0.2 fps
	Unloaded tip speed -- 2.0 fps
	Miss distance -- 2 inches

Table 3.11.4-1 Remote Manipulator System (RMS) Characteristics

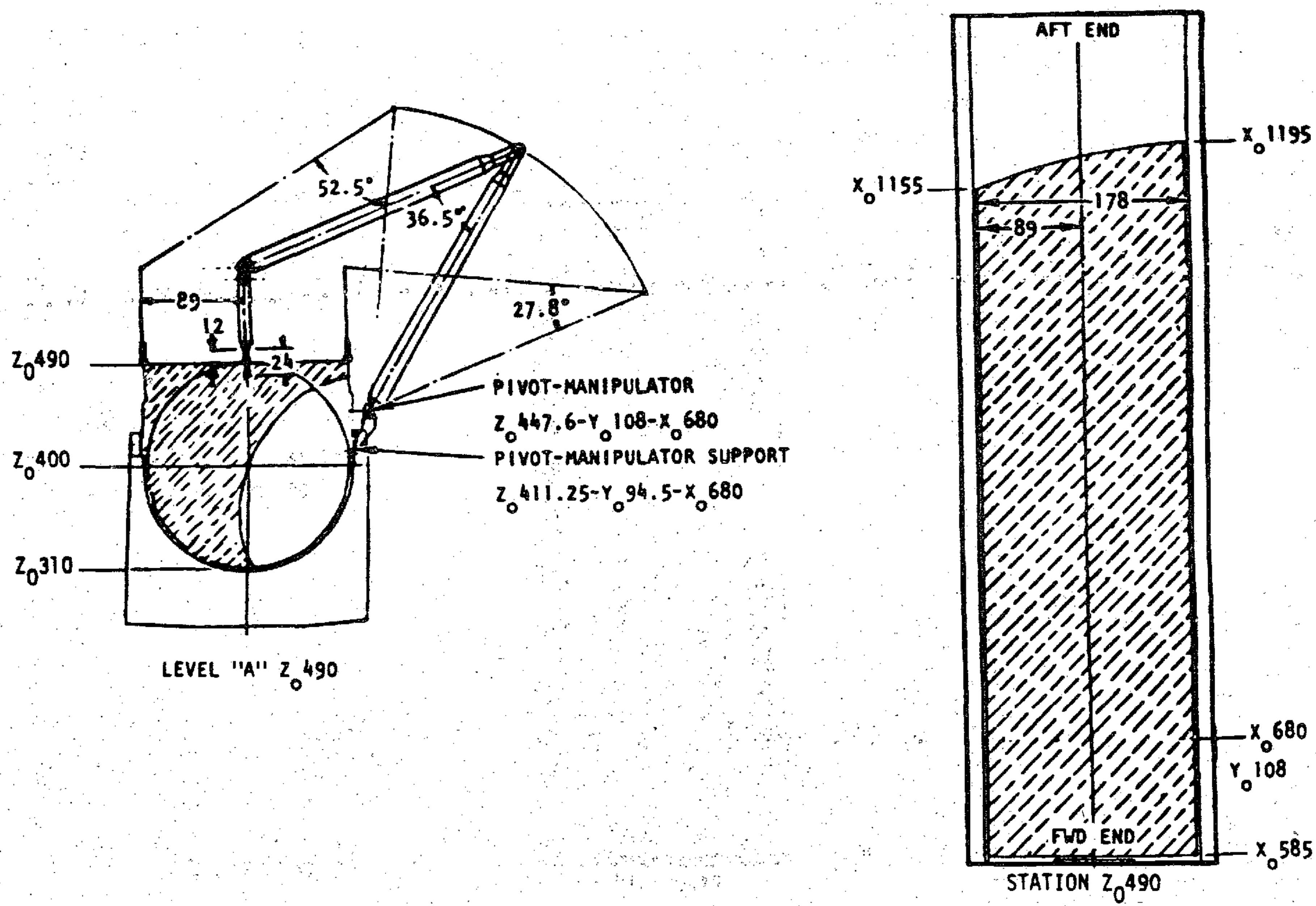


FIGURE ~~3.11.4-9~~REMOTE MANIPULATOR SYSTEM REACH CAPABILITY

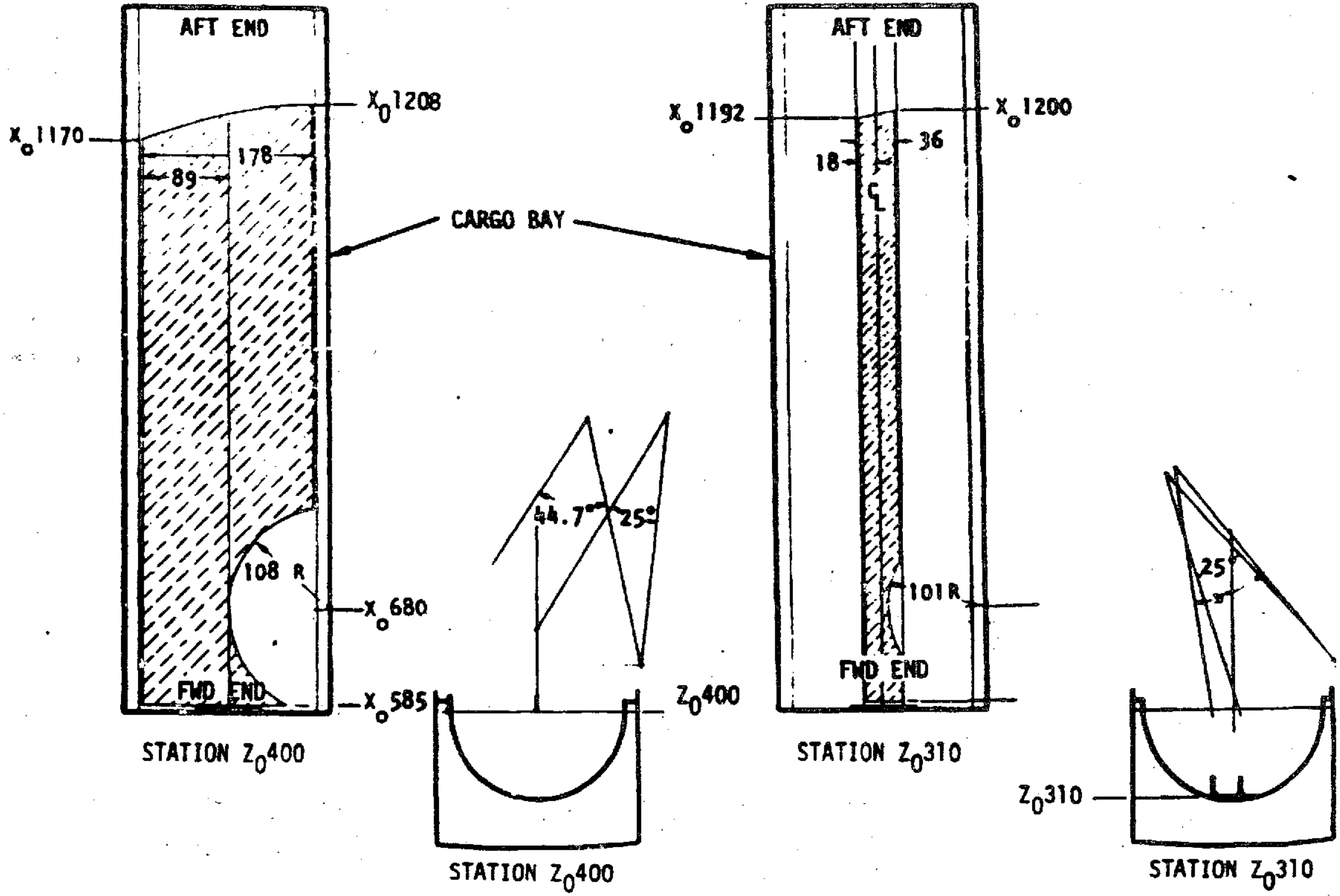


FIGURE 3.11.4-9 REMOTE MANIPULATOR SYSTEM REACH CAPABILITY (CONT)

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.11.5 Thermal						
3.11.5.1 The Orbiter will provide nominal payload bay environments, not considering EOS/Instruments heat addition or removal, as noted in Table 3.11.5-1	AC/10.5/10-2					●
3.11.5.2 The Orbiter will provide additional, active thermal control through a heat exchanger. The active heat rejection capacity dedicated to the EOS/Instruments is as follows: ● Average capacity - Nominal: 3400 Btu/hr - Peak: 5200 Btu/hr ● Orbital operations capacity (maximum) - Nominal: 11,250 Btu/hr - Peak: 21,500 Btu/hr	AC/8.3/8-2					●
3.11.5.3 During on-orbit operations, the EOS/Instruments will normally be exposed to the space environment	AC/10.5/10-2					●

CONDITION	DESIGN MINIMUM	DESIGN MAXIMUM
Prelaunch	+ 40°F	+ 120°F
Launch	+ 40°F	+ 150°F
On-orbit (doors closed)	See C&D	See A&B
Entry and postlanding	- 100° F	+ 200°F

Heat leak criteria into or out of a 100°F constant payload are as follows:

A. Total bay heat gain, average ≤ 0 Btu/ft2-hr

B. Heat gain, local area ≤ 3 Btu/ft2-hr

C. Total bay heat loss, average ≤ 3 Btu/ft2-hr

D. Heat loss, local area ≤ 4 Btu/ft2-hr

Table 3.11.5-1 Payload Bay Wall Thermal Environment

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	BC	DE	FG
3.12	DATA MANAGEMENT SYSTEM (DMS)										
3.12.1	The DMS shall contain the ground located EOS system operational elements that convey, handle, convert, distribute, and manage high-rate and edited lower rate spacecraft earth sensing instrument generated payload data.	CSC	●	●				●	●		
3.12.2	The DMS is composed of the following subsystems: o Instrument Data Acquisition & Recording o Data Processing & Product Generation o S/C & Processing Management & Control o Data User Services	CSC	○	○				○	○		
3.12.3	Two types of Data Acquisition & Data Processing configurations exist: o Primary or high data rate configuration composed of the Primary Ground Stations (PGS) and the Central Data Processing Facility (CDPF). o Secondary or Local User System (LUS) including the Low Cost Ground Station (LCGS) which receive compacted instrument data at lower rates than the PGS.	CSC	○	○				○	○		

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.13 FLIGHT OPERATIONS						
3.13.1 The EOS shall support retrieval by the Shuttle Orbiter	A/ 1.3.6/1-5 (TS 1) (TS 3)					●
3.13.2 The EOS shall provide for on-orbit servicing by the Shuttle Orbiter	A/ 1.3.6/1-5					●
3.13.3 The EOS shall provide for Level <u>TBD</u> autonomy	GAC (TS 7)					
3.13.4 All EOS venting while within <u>TBD</u> distance of the Shuttle Orbiter shall be non-propulsive	GAC (TS 3)					
3.13.5 Contaminants from EOS system effluents, including outgassing, shall not impinge harmfully upon: a. The instruments b. The Shuttle Orbiter	GAC					●
3.13.6 The EOS shall not discharge or jettison solid debris in orbit in the vicinity of instrument operations	GAC					●
3.13.7 Two hours shall be allotted between deployment from the Shuttle Orbiter and the first major EOS maneuver.	GAC					○
3.13.8 The EOS shall be targeted 10 n.mi above and 300 n.mi ahead of the Orbiter on the return from mission orbit for recovery	GAC (TS 1)					○
3.13.9 Three hours shall be allotted in all EOS mission timelines for Orbiter catch-up during EOS retrieval	GAC (TS 3)					○
3.13.10 The EOS shall maintain a stable attitude during Shuttle Orbiter terminal rendezvous and capture	GAC (TS 3)					○

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	BC	DE	FG
3.13.11 Contaminents from the launch vehicle shall not impinge harmfully upon the instruments	FA-2.16.3 FA-2.16.5.24	●	●	●	●	●				
3.13.12 Provide S/C health data during launch (max. q), subsequent L/V burns and during SRM firing.	FA-2.1,4,6, 10 & 19	○	○	○	○	○				

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.14 FLIGHT OPERATIONS SUPPORT						
3.14.1 Flight Operations Support (FOS) shall be capable of controlling two spacecraft in orbit concurrently	B/-/9 (TS 7&11)	○	○			
3.14.2 Maximize use of existing NASA facilities	GAC	○	○	○	○	○
3.14.3 Minimize use of mission-peculiar hardware/ software	GAC	○	○	○	○	○
3.14.4 Data acquisition, tracking, and orbit determination will be provided by GSFC.	A/2.1.6/2-7	●	●	●	●	●
3.14.5 Data acquisition facilities for complete U.S. coverage will be provided at three STDN sites: o Greenbelt, Maryland o Goldstone, California o Fairbanks, Alaska	A/2.1.6/2-7	○	○	○		
3.14.6 Communications with the primary and other data acquisition facilities will be via NASCOM	A/2.1.6/2-7	○	○	○	○	○
3.14.7 The Mission Control Center (MCC) shall be used for real-time support of the EOS, including operations scheduling.	B/-/9 (TS 11)	●	●	●	●	●

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.15 S/C GSE						
3.15.1 Factory						
3.15.1.1 The S/C will consist of three assemblies: Instrument, S/S Module & Orbit Adjust/Transfer, assembly therefore holding fixtures must be provided for each module during assembly and test.	V / - / 1	O	O	O	O	O
3.15.1.2 Provisions shall be made to assemble the S/C vertically for systems tests.	V / - / 1	O	O	O	O	O
3.15.1.3 Provide bench checkout equipment for each of the three basic S/S modules: ACS, EPS, Comm. & Data Handling	W / - / 2	O	O	O	O	O
3.15.1.4 Provide power to S/S modules, which simulates S/C power, variable within S/C limits	W / - / 2	O	O	O	O	O
3.15.1.5 Provide loads to the S/S modules during test, which simulates S/C interfaces	W / - / 2	O	O	O	O	O
3.15.1.6 Provide work stands for vehicle assembly and checkout	W / - / 2	O	O	O	O	O
3.15.2 Launch Site						
3.15.2.1 Provide flexibility in the design of bench checkout equipment so that its use can grow to a module maintenace bench during Shuttle operations	W / - / 2	O	O	O	O	O
3.15.2.2 Provide for conditioning of S/C flight batteries	W / - / 2	O	O	O	O	O

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.16 S/C TO DELTA 2910 INTERFACES						
3.16.1 Structural/Mechanical						
3.16.1.1 The EOS shall attach to the Delta 2910 launch vehicle attach fitting via:	T/3.2/3-4	○	○			
a. A two-piece marman clamp arrangement						
b. A four-bolt attachment arrangement						
3.16.1.2 The EOS shall accept a relative separation velocity of 2-8 ft/sec (0.61 - 2.4 m/s).	T/3.2/3-4	●	●			
3.16.1.3 The EOS shall fit within the payload envelope defined in Fig. 3.17-1	T/Fig. 3-60/3-70 U/Fig. VI-6/VI-9	●	●			
3.16.1.4 The EOS shall withstand a maximum steady state longitudinal acceleration of 8.3 g's.	T/3.6.3.5.3/3-10	●	○			
3.16.2 Communication & Data Handling						
3.16.2.1 Spacecraft separation is initiated directly from the guidance computer after SECO. It can provide up to six programmed signals to accomplish various functions. Two of the signals are within the range of 30 to 160 sec. after initiation with an accuracy of a 0.5 sec. or 0.5% of the specified set time, whichever is greater. The remaining four programmed signals can be set from 1 to 50 sec. after either of the first two signals with an accuracy of ± 10%.	T/1-8/1.3.1 & 2					

7

Note:

Projection of S/C appendages below the S/C separation plane are permitted but must be coordinated with the Delta project

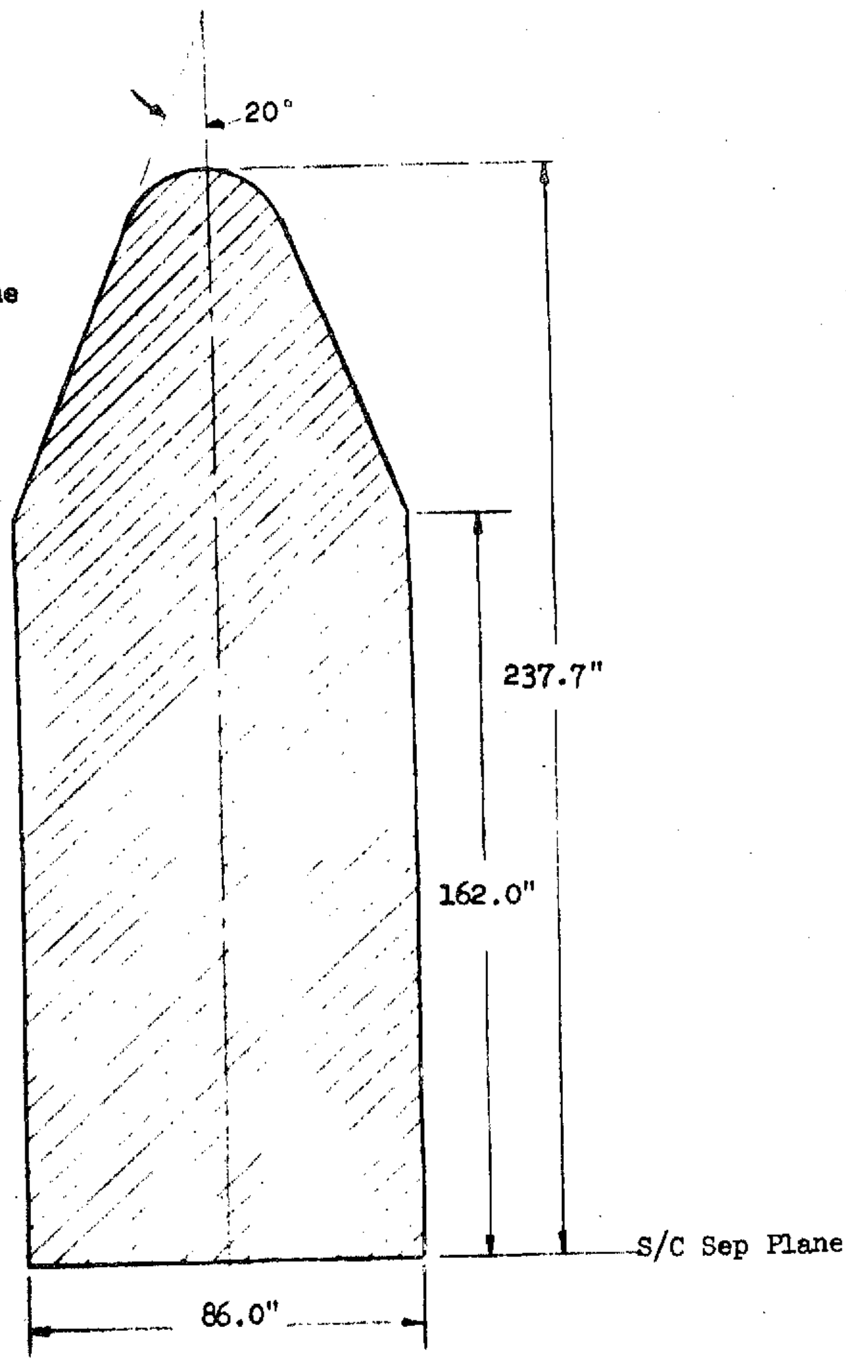


Fig. 3.16-1 Allowable Payload Envelope, Delta 2910

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.17 S/C to Titan III B/SSB/NUS						
3.17.1 Communications and Data Handling						
3.17.1.1 The Launch vehicle can provide up to 16 discrete outputs, sequenced on the basis of time or event dependency, for S/C control. Maximum output current is 10 amps.	AB/VII/VII-6			O		
3.17.1.2 Telemetry data transmitted through the launch vehicle shall conform to the characteristics of Table 3.17.-1	AB/VII/VII-7			O		
3.17.2 Electrical Power						
3.17.2.1 EOS electrical demands upon the launch vehicle shall be consistent with the power system characteristics defined in Table 3.17-2.	AB/VII/VII-5			O		
3.17.2.2 All power leads from the EOS to the launch vehicle shall be: a. Physically separated from other wiring b. Isolated from EOS structure by at least 10 megohms.	AB/VII/VII-7			O		

DATA TYPE	IMPLEMENTATION	NUMBER OF AVAILABLE CHANNELS	SAMPLE RATE (SPS)
Bilevel On, 4 to 35 vdc Off, -5 to 0.6 vdc	In Remote Multiplexed Instrumentation System	6 6 8	1600 400 100
Analog 0 to 40 mvdc input 8-bit D/A output	In Each Remote Multiplexer Unit	2 4 4 4 8 10	800 400 200 100 40 20

Table 3.17-1 Typical Titan III B/SSB S/C Instrumentation Services

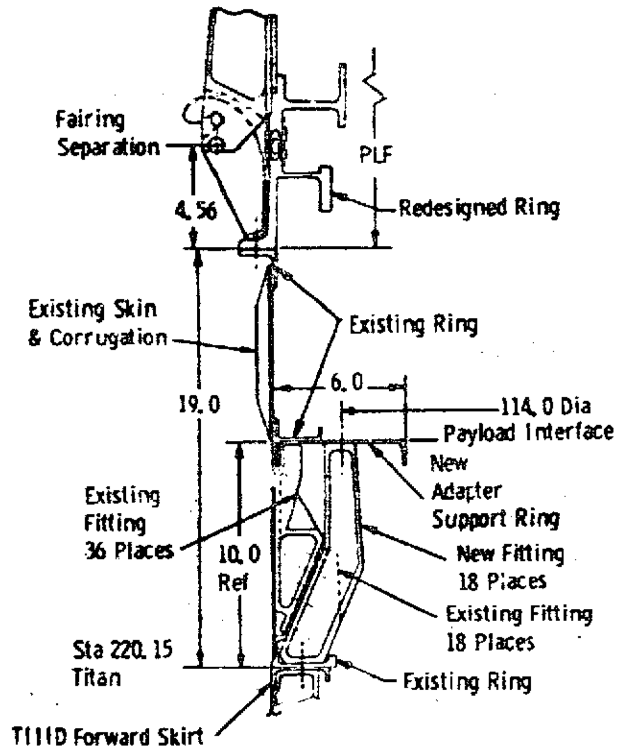
CONSIDERATION	MULTIBUS POWER SYSTEM (STEADY STATE)	TRANSIENT POWER SYSTEM
Power available to spacecraft	5 amp-hr at 28 vdc	4 amp-hr at 28 vdc
Voltage	25 to 32 VDC	20 to 38 vdc
Noise and ripple	30 H_z to 20 KH_z, with peak of 2.0v on gnd pwr and peak of 1.25v on airborne pwr	No constraints
Special considerations	Not to be used for spacecraft transient power loads	High-transient-current capacity, suitable for firing ordnance, driving motors, etc.

Table 3.17-2, Titan III B/SSB S/C Electrical Power Services (Estimated)

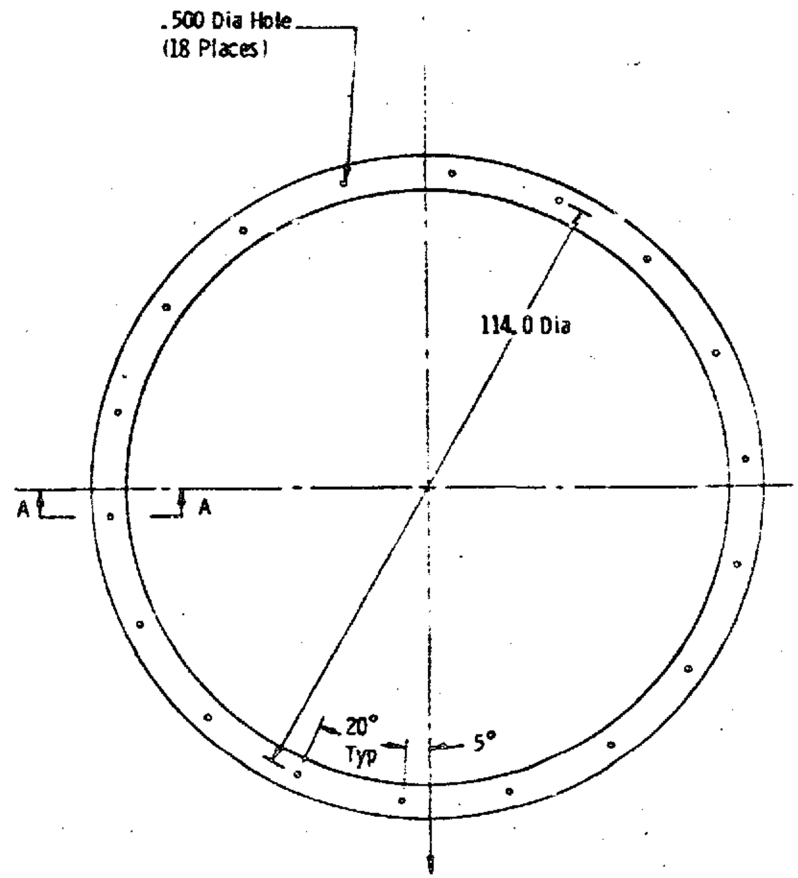
REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.17.3 Attitude Control						
3.17.3.1 The launch vehicle shall control attitude at separation to the following limits:	AB/VII/VII-8			C		

Pointing (deg)	Rate (deg/sec)
± 0.5	± 0.45 Pitch, Yaw
	± 0.75 Roll
± 2.0	± 0.1 Pitch, Yaw
	± 0.2 Roll
± 4.0	± 0.1 Pitch, Yaw
	± 0.2 Roll

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
3.17.4 Structural/Mechanical						
3.17.4.1 The EOS shall structurally interface with the launch vehicle as shown in Fig. 3.17-1	AE/-/7			O		
3.17.4.2 The impulse to separate EOS from the launch vehicle shall be provided by a spring-driven separation system carried by and charged to the EOS.	AB/VII/VII-8			O		
3.17.4.3 The EOS shall fit within the payload envelope defined in Fig. 3.17-2 and 3	U/Fig VI-6/VI-9 AE/-/8			O		



Section A-A



Target
View Looking Aft
Payload Interface

Figure 3.17-1

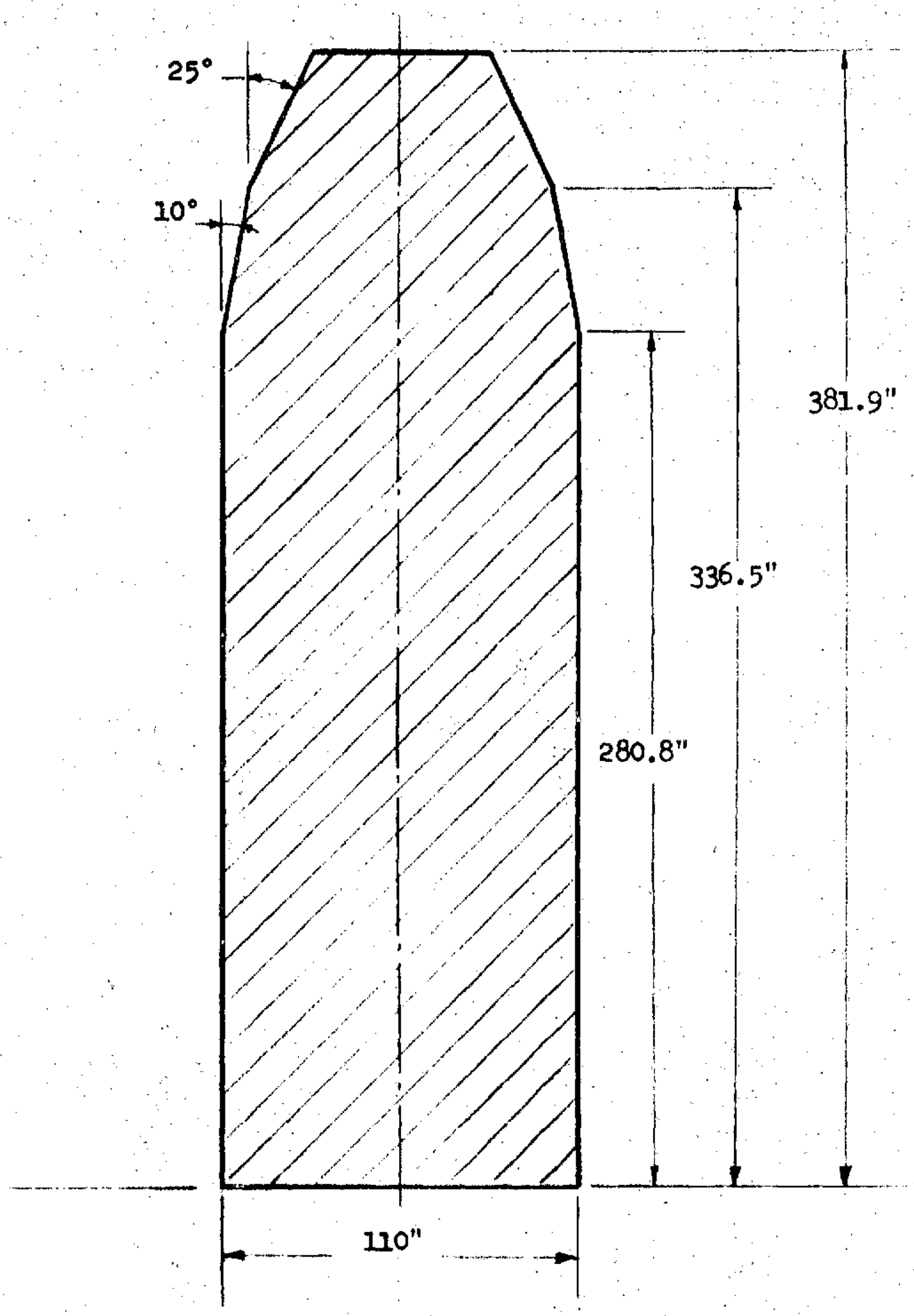
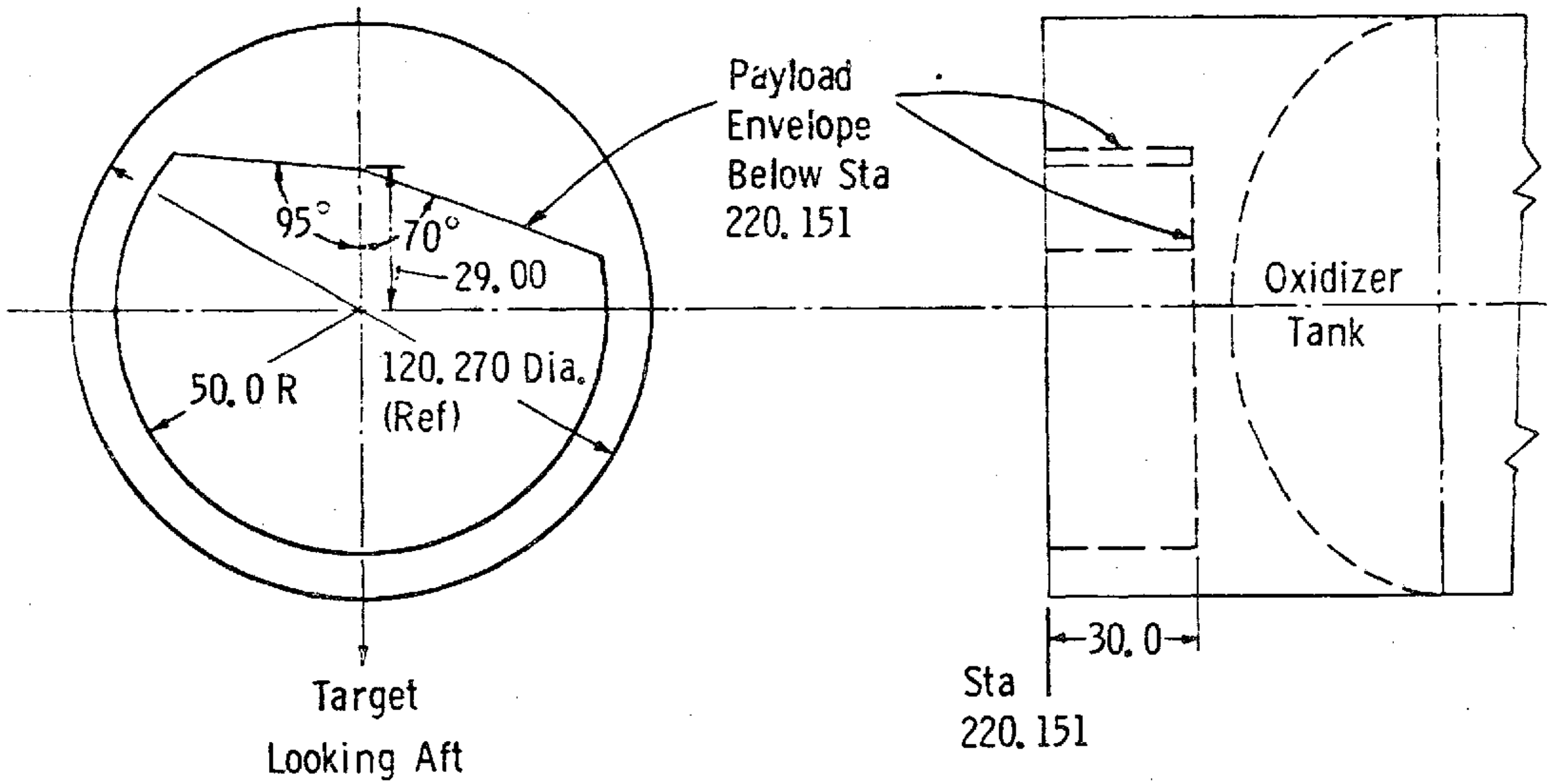


FIG. 3.17 - 2 Allowable Payload Envelope, Titan IIIB/SSB/NUS For WTR
Type P 123 Seg. A,D,E, and G

Titan IIIB or IIID



Note: All dimensions and Sta. No.'s are in inches.

Figure 3.17-3

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
3.18	SPACECRAFT TEST REQUIREMENTS						
3.18.1	Component Dynamic Enviromental Requirements	V/Appendix I/-	O	O	O	O	
3.18.1.1	Transportation and Handling The component shall be capable of operating within specification limits after exposure to controlled environments, while in a non-operating mode during transportation and handling. Controlled environments shall be provided by properly designed shipping containers to insure that the experienced transportation and handling levels are less severe than those pertaining to launch and orbital mission phases.						
3.18.1.1.2	Fabrication Shock In accordance with MIL-STD-810B, Method 516.1, Procedure V.						
3.18.1.1.3	Transportation Shock In accordance with MIL-STD-810B, Method 516.1, Paragraph 3.9.5						
3.18.1.1.4	Transit Shock In accordance with MIL-STD-810B, Method 516.1 Procedure II						
3.18.1.1.5	Sinusoidal Vibration In accordance with MIL-STD-810B, Method 514.1, Procedure X. The test levels shall be as indicated in Figure 516.1-7, curve "AW" and "AY." The test procedure and duration shall be as indicated in Table 514.1 - VII.						

REQUIREMENT		SOURCE	OPTION 1 2 3 4 5
3.18.1.2	Qualification Environments The component shall be capable of operating within specification limits during and after exposure to the following environments.		
3.18.1.2.1	Acceleration The test levels shall be 20_g applied for one minute in each direction along each of the three orthogonal axes.		
3.18.1.2.2	Acoustic Field The test levels and duration shall be as shown in Table 3.18.1-1. Acoustic tests shall be conducted in lieu of the random vibration test only on selected components which are likely to be susceptible to acoustic noise excitation (e.g.. antennas, solar panels).		
3.18.1.2.3	Random Vibration The test levels and duration shall be as shown in Table 3.18.1-2. The levels and duration shall be applied along each of the three orthogonal axes.		

REQUIREMENT		SOURCE	OPTION 1 2 3 4 5
3.18.1.2.4	**Sinusoidal Vibration** The test levels and logarithmic frequency sweep rate shall be as shown in Table 3.18.1-3. The levels and sweep rate shall be applied along each of the three orthogonal axes. Note: In lieu of the 200-2000Hz portion of the sinusoidal vibration test, a shock test (3.18.1.2.5) is preferred.		
3.18.1.2.5	**Shock** A shock spectral analysis, using Q=10, of the applied shock transient shall be in accordance with the shock response spectrum shown in Figure 3.18.1-4. A sufficient number of shocks shall be imposed to meet the amplitude criteria in both directions along each of the three orthogonal axes at least three times (total of 18 shocks).		

TABLE 3.18.1-1

ACOUSTIC QUALIFICATION TEST LEVELS

Duration: 3 minutes

*(dB Re: 20 μ Newton/m^2)

OCTAVE BAND	
Center Frequency (Hz)	Sound Pressure Level (dB*)
31.5	131
63	137
125	142
250	144
500	143
1000	141
2000	137.5
4000	135
8000	133
OVERALL	149.5

4

TABLE 3.18.1-2

RANDOM VIBRATION

QUALIFICATION TEST LEVELS

Duration: 3 Minutes/axis

Frequency Range (Hz)	Acceleration Spectral Density (g^2/Hz)	Acceleration Overall (g-rms)
20-150	+3dB/Oct	16
150 -1000	0.18	
1000-2000	-6dB/Oct	

TABLE 3.18.1-3

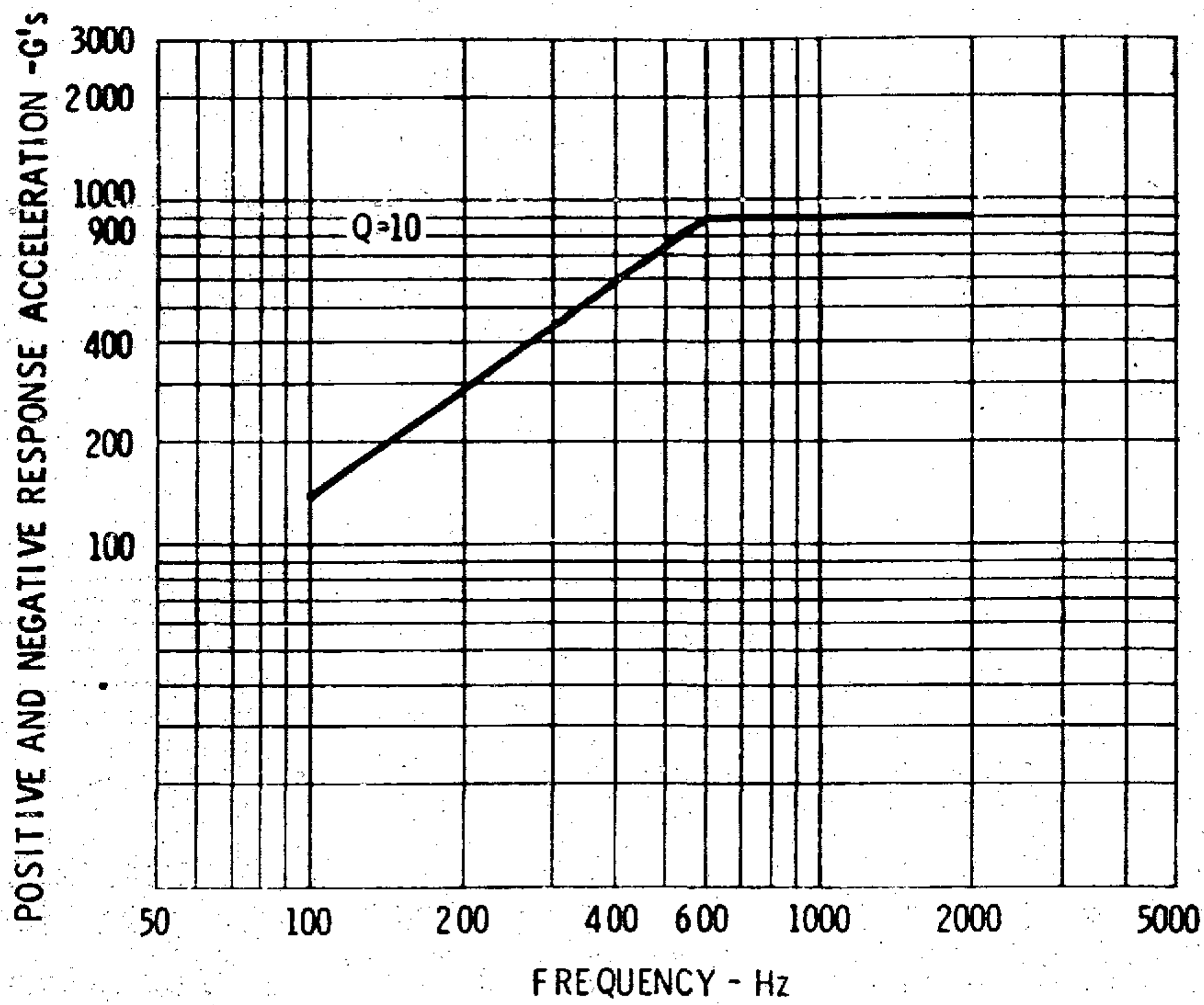
SINUSOIDAL VIBRATION

QUALIFICATION TEST LEVELS

Sweep Rate: 2 Octaves/Minute/Axis

Frequency Range (Hz)	Acceleration Zero -to-Peak (g)
5-9.5	12.7 mm d.a.
9.5-15	± 2.3
15-21	± 6.0
21-50	± 10.0
50-200	± 2.3
200-2000	± 5.0

FIGURE 3.18.1-1



REQUIREMENT		SOURCE	OPTION 1 2 3 4 5
3.18.1.3	Acceptance Test Environment		
3.18.1.3.1	General		
3.18.1.3.1.1	Flight Components Flight components, which are tested later as part of a completely assembled flight spacecraft, shall be subjected to random vibration or, where applicable, to acoustic noise tests.		
3.18.1.3.1.2	Flight Spare Components Flight spare components that have not been exposed to system tests as part of a prototype or backup spacecraft shall be subjected to both sinusoidal and random vibration.		
3.18.1.3.2	Acoustic Field The test levels and duration shall be as shown in Table 3.18.1-4. Acoustic tests shall be conducted in lieu of the random vibration test only on selected components which are likely to be susceptible to acoustic noise excitation (e.g., antennas, solar panels).		
3.18.1.3.3	Random Vibration The test levels and duration shall be as shown in Table 3.18.1-5. The levels and duration shall be applied along each of the three orthogonal axes.		
3.18.1.3.4	Sinusoidal Vibration The test levels and logarithmic frequency sweep rate shall be as shown in Table 3.18.1-6. The levels and sweep rate shall be applied along each of the three orthogonal axes.		

TABLE 18.1-4 ACOUSTIC ACCEPTANCE TEST LEVELS

Duration: 1 minute
*(dB Re: 20 μ Newton/m^2)

OCTAVE BAND	
Center Frequency (Hz)	Sound Pressure Level (dB*)
31.5	127
63	133
125	138
250	140
500	139
1000	137
2000	133.5
4000	131
8000	129
OVERALL	144.5

4

TABLE 3.18.1-5 **RANDOM VIBRATION**

ACCEPTANCE TEST LEVELS

Duration: 1 Minute/Axis

Frequency Range (Hz)	Accleration Spectral Density (g^2/Hz)	Acceleration Overall (g-rms)
20-150 150-1000 1000-2000	+3dB/Oct 0.072 -6dB/Oct	10

TABLE 3.18.1-6 SINUSOIDAL VIBRATION

ACCEPTANCE TEST LEVELS

Sweep Rate: 4 Octaves/Minute/Axis

Frequency Range (Hz)	Acceleration Zero-to-Peak (g)
5-9.5	8.4 mm d.a.
9.5-15	± 1.5
15-21	± 4.0
21-50	± 6.6
50-200	± 1.5
200-2000	± 3.3

REQUIREMENT		SOURCE	OPTION 1 2 3 4 5
3.18.2	Spacecraft Dynamic Environmental Requirements	AG/append. I/-	
3.18.2.1	Transportation and Handling The Spacecraft shall be capable of operating within specification limits after exposure to controlled induced environments, while in a non-operating mode during transportation and handling. Controlled environments shall be provided, by properly designed shipping container, proper selection of modes of transportation and handling methods, to ensure that transportation and handling do not impose environmental conditions which exceed the maximum predicted launch and orbital mission requirements. Controlled environments shall be provided to protect the Spacecraft against the following conditions (TBD).		
3.18.2.2	Qualification Test Environments The Spacecraft qualification test article shall be subjected to the environments specified below and in accordance with the requirements of NASA GSFC S-320-G-1 except as noted. The Spacecraft shall be examined and functionally tested before and after each environmental exposure. During the test, the Spacecraft shall be operated in the appropriate mission phase duty cycle.		
3.18.2.2.1	Acoustic Field The Spacecraft shall be exposed to a broadband random sound field with an overall sound pressure level of 149 dB (Re: 20 μ Newton/m^2). The octave band sound pressure levels shall be as specified in Table 3.18.2-1 The Spacecraft shall be mounted on a flight-type adapter during the test.		

REQUIREMENT	SOURCE	OPTION 1 2 3 4 5

3.18.2.2.2 Sinusoidal Vibration

The Spacecraft shall be attached to a vibration fixture using a flight-type adapter and flight-type clamp. Sinusoidal vibration excitation shall be applied at the base of the adapter along each of the three orthogonal axes. The test levels and logarithmic frequency sweep rate shall be as shown in Table 3.18.2-2. The reduction of the sinusoidal vibration test levels, in the Spacecraft's resonant frequency band, will be required in order to prevent the application of unrealistic loads. This "notching" of the input levels shall be determined by dynamic analysis of the Spacecraft in combination with the Launch Vehicle.

3.18.2.2.3 Mechanical Shock

The Spacecraft shall be subjected to a mechanically applied shock transient to the Spacecraft/Launch Vehicle interface twice along each of the three orthogonal axes. The test level, using shock spectral analysis with a Q = 10, shall be defined in terms of shock response spectrum and in accordance with Figure 3.18.2-1

3.18.2.2.4 Protechnic Shock

The Spacecraft shall be subjected to two pyrotechnic separation tests. In addition to the Spacecraft, the test shall include the flight-type adapter, flight-type clamp and pyrotechnic devices. The Spacecraft shall also be subjected to additional pyrotechnic shocks dependent on the type and quantity of release devices used for solar arrays, antennas, etc.

REQUIREMENT		SOURCE	OPTION
			1 2 3 4 5
3.18.2.2.5	<u>Static Load</u> The Spacecraft structural model shall be subjected to a static load test. The test levels to be applied shall be determined from a combined Spacecraft/Launch Vehicle dynamic loads analysis, Spacecraft structural loads and stress analyses for the worst case conditions of Tables 3.18.2-3, 4, & 5.		
3.18.2.2.6	<u>Modal Survey</u> The test is a developmental engineering test and not a qualification test. modal survey of the Spacecraft, with installed mass simulation of components, shall be performed to determine the natural frequencies, mode shapes, and structural damping. This shall be a cantilever test with the Spacecraft structure (including the attach fitting) mounted on a fixed base.		
3.18.2.3	<u>Acceptance Test Environments</u> Each Flight Spacecraft shall be subjected to the environment specified below and in accordance with the requirements of NASA GSFC S-320-G-1 except as noted. The Spacecraft's components shall be operating and monitored for identification of intermittent failure.		
3.18.2.3.1	<u>Acoustic Field</u> The Flight Spacecraft shall be exposed to a broadband random sound field. The Octave band sound pressure levels shall be as specified in Table 3.18.2-6 . The spacecraft shall be mounted on a flight-type adapter during the test.		

TABLE 3.18.2-1

ACOUSTIC NOISE

SPACECRAFT QUALIFICATION TEST LEVELS

*(dB Re: 20 μ Newton/M^2)

OCTAVE BAND	
Center Frequency (HZ)	Sound Pressure Level (dB*)
31.5	131
63	137
125	142
250	144
500	143
1000	141
2000	137.5
4000	135
8000	133
Overall	149.5
Duration: 2 Minutes	

TABLE 3.18.2-2

SINUSOIDAL VIBRATION

SPACECRAFT QUALIFICATION TEST LEVELS

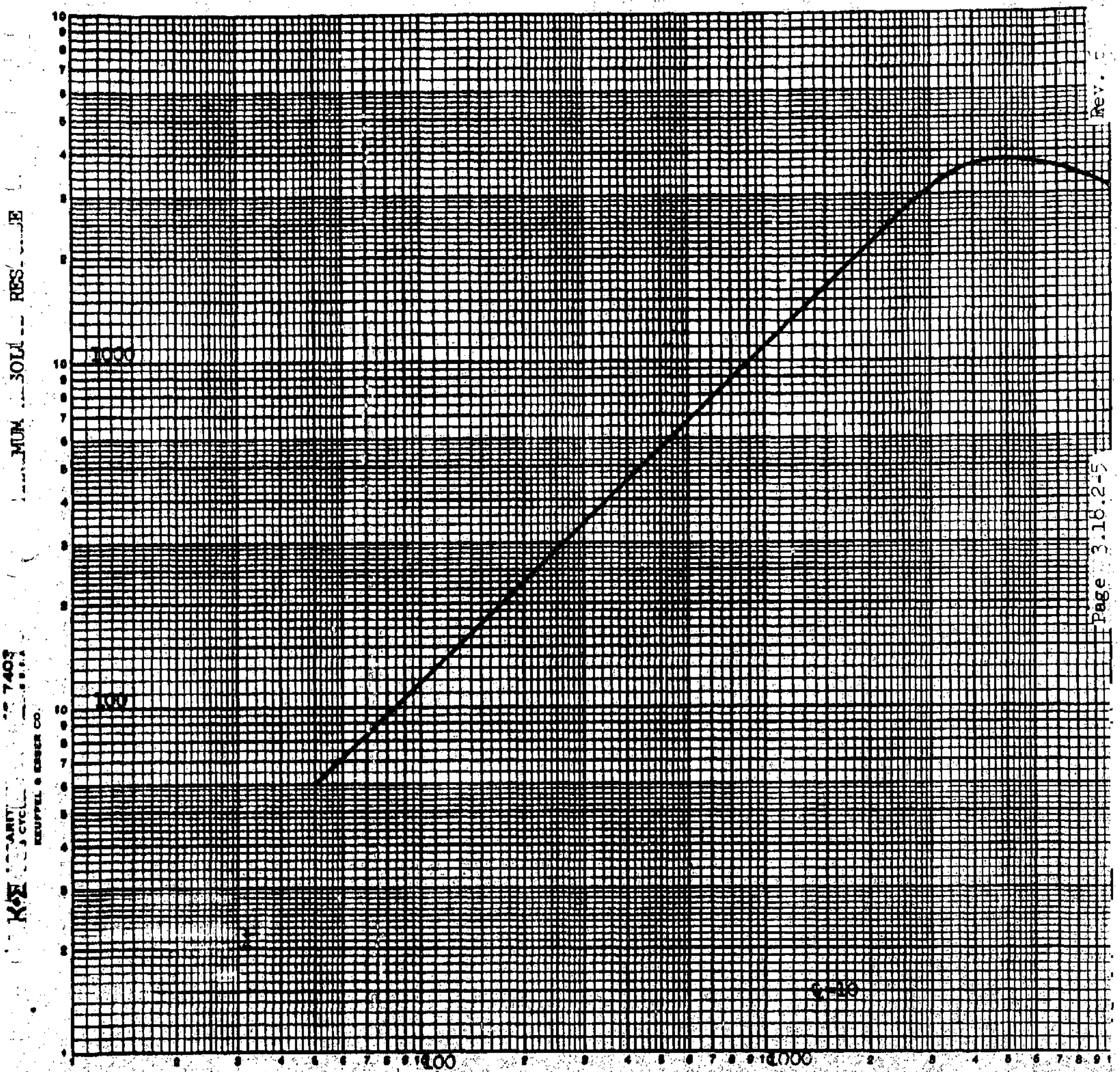
Axis of Excitation	Frequency Range (HZ)	Acceleration Zero-to-peak $\pm$ (g)
Longitudinal (X-X)	5 - 9.5	12.7 mm d.a.
	9.5 - 15	2.3
	15 - 21	6.0
	21 - 50	3.0
	50 - 200	2.3
Lateral (Y-Y) & (Z-Z)	5 - 7.1	19.0 mm d.a.
	7.1 -22	2.0
	22 - 200	1.5
Sweep Rate: 2 Octaves/Minute		

FIGURE 3.18.2-1

SHOCK RESPONSE SPECTRUM

AT SPACECRAFT/LAUNCH VEHICLE INTERFACE

LAUNCH VEHICLE INDUCED SHOCKS



FREQUENCY - H_z

QUALIFICATION TEST LEVELS

TABLE 3.18.2-3

ULTIMATE LOAD FACTORS

DELTA LAUNCH VEHICLE

Condition	Longitudinal X	Lateral Y or Z
Lift - off	+ 4.35 - 1.5	3.0
Main Engine Cut off	+ 18.45	1.0

TABLE 3.18.2-4

ULTIMATE LOAD FACTORS

TITAN III B/NUS LAUNCH VEHICLES

Condition	Longitudinal X	Lateral Y or Z
Lift - off	+ 3.45 - 1.2	3.0
Stage I shutdown (depletion)	+12.3 - 3.75	2.25
Stage II shutdown (command)	+ 16.2 - 3.0	2.25

Notes:

1. Limit load factor times 1.5
2. Load factor carries the sign of the externally applied load.
3. Includes both steady state and dynamic conditions.

TABLE 3.18.2-5

ULTIMATE LOAD FACTORS (1)

SHUTTLE

Condition	Directions (2)		
	X	Y	Z
Lift - off (4)	+ 2.55 ± 0.9	± 0.45	+ 1.20 + 0.30
High Q Boost	+ 2.85	± 0.30	- 0.30 + 0.75
Booster End Burn	+ 4.5 ± 0.45	± 0.30	+ 0.60
Orbiter End Burn	+ 4.5 ± 0.45	± 0.30	+ 0.75
Space Operations	+ 0.30 - 0.15	± 0.15	± 0.15
Entry	± 0.38	± 0.75	- 4.5 + 1.5
Subsonic Manenvering	± 0.38	± 0.75	- 3.75 + 1.5
Landing and Braking	± 2.25	± 2.25	- 3.75
Crash (3)	- 9.5 + 1.5	± 1.5	- 4.5 + 2.0

Notes:

1. Limit load factor times 1.5 except for crash.
2. Load factor carries the sign of the externally applied factor. Positive X, Y, Z, directions equal forward, right and down.
3. Crash load factors are ultimate and only used to design local payload support fittings and attachments. The specified load factors shall apply separately.
4. These factors include dynamic transient load factors.

TABLE 3.18.2-6

ACOUSTIC NOISE

SPACECRAFT ACCEPTANCE TEST LEVELS

OCTAVE BAND			
Center Frequency (HZ)	Sound Pressure Level dB (dB Re: 20 μ Newton/M^2)		
	Level I	Level II	Level III
31.5	124	127	127
63	125	132.5	133
125	130	137	138
250	135	139	140
500	139	139	139
1000	133	137	137
2000	130	133.5	133.5
4000	126	130	131
8000	123	124	129
OVERALL:	142	145	145.5
DURATION: 1 Minute			

Level	Options		
	1	2	3
I	*		
II		*	
III			*

SUBSYSTEM REQUIREMENTS

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.1.1	Orbit Adjust						
4.1.1.1	Provide thrusters, propellant storage and controls to effect orbit adjustment	G/3.2.2.2.2/3-35	●	●	●	●	●
4.1.1.2	Provide + x impulse (lb-sec) requirements as follows:	AF/Table 4,6,7/-	●	●	●		

Maneuver	Option 1	2	3
Correct injection error	3374	4070	6403
Correct SRM error			522
Orbit keys	108	140	168
Contingency 10%	348	421	704
Total	3830	4631	7802

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.1.1.3	Provide SRM for orbit insertion	G/3.2.2.2/3-35			●		
4.1.1.4	The orbit adjust subsystem shall consist of four 75 lb thrusters which shall be used to maintain control during SRM operations	G/Fig. 3-12/3-25			●		
4.1.1.5	For non SRM operations provide four 5 lb thrusters	GAC	●	●			

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.1.2	Communications and Data Handling						
4.1.2.1	The variable downlink TLM rates are 32, 16, 8, 4, 2, 1 kbps	B/-/20	O	O	O	O	O
4.1.2.2	The 8 GHz (X-band) frequency should be utilized	F/2.2.2.1.3/- B/-/21	O	O	O	O	O
4.1.2.3	Use 95% link reliability for sizing the X-band link	B/-/21	O	O	O	O	O
4.1.2.4	The complete optional payload for EOS-B will acquire data at a continuous rate of up to 2.5 Mbps, with individual instrument data ranging from 100 bps to 2.0 Mbps	A/2.3.2/2-9	O	O	O	O	O
4.1.2.5	Provide for STDN compatible, S-band experiment data transmission at the following rates: a. Real-time 6.4 Kbps b. Stored/playback 128 Mbps	M/3.3.3.4/16	O	O	O	O	O
4.1.2.6	Provide a command system with both discrete (single) pulse and serial magnitude word capability	M/3.3.3.4/16	O	O	O	O	O
4.1.2.7	Provide for variable formatting of experiment and spacecraft data upon command	M/3.3.3.4/16	O	O	O	O	O
4.1.2.8	Provide on-board storage for at least two orbits of experiment and subsystem data	M/3.3.3.4/16	O	O	O	O	O
4.1.2.9	Provide for simultaneous transmission of real-time and playback telemetry	M/3.3.3.4/16	O	O	O	O	O
4.1.2.10	Provide an on-board processor for command memory and for use by experiments and EOS subsystems	M/3.3.3.4/16	O	O	O	O	O
4.1.2.11	The EOS on-board processor, with associated hardware, shall provide for: a. Stored commands	M/3.3.3.4/16	O	O	O	O	O

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5	A	B	C	D	E	F
4.1.2	Communications and Data Handling (Cont'd)												
	b. Automatic interaction between experiment data and spacecraft subsystem modes												
4.1.2.12	Provide for maximum instrument data rates of 60 Mbps	N/ - / -					○						
4.1.2.13	Provide for two discrete levels of instrument data transmission: a. 0.5 Kbps Real Time b. 10 Mbps Stored/playback	O/ - / -	○								○		
4.1.2.14	Provide a means for tracking, ground and on-board control of all spacecraft and payload sensor functions, and for retrieval of observatory data.	F/II,2.1/-	●	●	●	●	●						
4.1.2.15	An S-band transponder shall be used for ranging, receiving, commanding, and transmitting narrow band sensor and housekeeping data.	F/II,2.2.1/-	○	○	○	○	○						
4.1.2.16	All communications shall be fully compatible with the GSFC Aerospace Data System Standards X-560-63-2	F/II,2.2.1/-	○	○	○	○	○						
4.1.2.17	Frequency assignments shall be made on a mission-by-mission basis: a. Transmit 2200 MHz to 2300 MHz b. Receive 2050 MHz to 2150 MHz	F/II,2.2.1/-	○	○	○	○	○						
4.1.2.18	The probability of executing a false command shall be less than 10^{-10} for any input signal conditions.	F/II,2.2.1.2/-	○	○	○	○	○						
4.1.2.19	The probability of rejecting a good command shall be less than 10^{-3} over a signal range of -105 to -40 dbm.	F/II,2.2.1.2/-	○	○	○	○	○						

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
4.1.2.20	The S-band transmitter shall be capable of simultaneously transmitting: o 32 kbps real-time, low rate housekeeping/sensor data o Up to 640 kbps stored/playback medium rate data	F/II,2.2.1.3/-	O	O	O	O	O
4.1.2.21	The C&DH system shall be capable of simultaneously distributing within the S/C, 62.5 cmds/sec from the on-board computer while executing 50 cmds/sec from the ground.	F/II,2.2.1/-	O	O	O	O	O
4.1.2.22	The C&DH system shall be capable of simultaneously acquiring up to 32 kbps of S/C data for the computer only and acquiring up to 32 kbps of additional S/C data for transmission to both the ground and the on-board computer.	F/II,2.2.2/-	O	O	O	O	O
4.1.2.23	RF characteristics shall be as defined in Table 4.1.2-1	F/II,2.2.2/-	O	O	O	O	O
4.1.2.24	A general purpose digital computer shall be included in the C&DH subsystem	F/II,2.2.3/-	O	O	O	O	O
4.1.2.25	Assure that all receivers cannot be turned off simultaneously when activated for flight	FA-2.16.6					

Transmit Frequency	TBD MHz $\pm$.001% (S-Band)
Receive Frequency	TBD MHz (S-Band)
Turnaround Ratio	221/240
Transponder Sidetone Frequency	500 KHz maximum
Command Bit Rate	2000 bps
Command Modulation	PCM/PSK - Σ/FM/PM (Uses 70KHz subcarrier)
Narrow Band Data Rate	Selectable: 32 kbps, 16 kbps, 8 kbps, 4 kbps, 2 kbps & 1 kbps
Narrow Band Modulation	Split phase PCM/PM on subcarrier
Medium Band Data Rate	500 kbps maximum
Medium Band Data Modulation	Split phase PCM/PM on carrier
Transmitter Power	2 watts, & .2 watts
T/M Data Coding	Manchester (split phase)

BASELINE RF CHARACTERISTICS

TABLE 4.1.2-1

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.1.3	Electrical Power Subsystem						
4.1.3.1	The EPS shall be capable of controlling, storing, distributing & monitoring power derived from a solar array. The physical & electrical characteristics of the array will be based on individual mission and power subsystem requirements. The subsystem shall contain storage batteries and all associated charge/discharge control and monitoring circuitry.	F/III,2.1/-	●	●	●	●	●
4.1.3.2	Electrical interfaces of subsystem modules shall be standardized	E/2.1/2-1	○	○	○	○	○
4.1.3.3	All S/C power will be supplied by a solar array	E/3.1/3-1	○	○	○	○	○
4.1.3.4	The power output of the array will be adequate to supply normal daylight loads plus recharge the batteries	E/3.1/3-1	○	○	○	○	○
4.1.3.5	Bus voltage shall be 28 ± 7 DC	E/3.2.1.1/3-8	○	○	○	○	○
4.1.3.6	Bus transients: Load switching ± 1V for 100 ms or less Fault correction +20 to +39 V for 100 ms or less	E/3.2.1.4/3-8	○	○	○	○	○
4.1.3.7	Bus Noise & Ripple: Due to EPS less than 500 mv peak to peak, 5 Hz to 100 KHZ Due to EOS loads TBD	E/3.2.1.5/3-8	○	○	○	○	○
4.1.3.8	Operating temperature range for equipment will not exceed: electronic assys. 0 to 130°F batteries 32 to 60° F	E/3.2.9/3-11	○	○	○	○	○
4.1.3.9	Fuses will be operated at 20% of rated current	E/3.3.5/3-30	○	○	○	○	○

	REQUIREMENT	SOURCE	OPTION				
			1	2	3	4	5
4.1.3.10	EPS shall be designed to automatically maintain a safe state of charge in the batteries for normal orbital operations. Capability shall be provided via command circuitry for overriding all automatic functions except those considered necessary for normal operation or survival of the spacecraft during emergency conditions.	F/III,2.2.3/-	●	●	●	●	●
4.1.3.11	The power distribution bus shall supply power to the subsystems and instruments. Common impedences in the distribution circuitry shall be as low as practical to minimize the coupling of conducted interference between loads.	F/III,2.2.4/-	○	○	○	○	○
4.1.3.12	The distribution circuitry for subsystem loads shall contain devices to protect power busses from short circuits. The bus protection circuitry shall be provided for all loads except those which are non-redundant and/or critical to mission success.	F/III,2.2.4.1/-	○	○	○	○	○
4.1.3.13	Individual groups of power contacts shall be provided for each major subsystem and instruments	F/III,2.2.4.2/-	○	○	○	○	○
4.1.3.14	Current sensors shall be provided for monitoring load currents supplied to each subsystem & instrument.	F/III,2.2.4.3/-	○	○	○	○	○
4.1.3.15	Power subsystem shall contain circuitry for arming & disabling the power input/output circuitry during ground tests & during orbital resupply	F/IV,2.2.5/-	○	○	○	○	○
4.1.3.16	The subsystem shall have the capability for being powered by ground or shuttle orbiter based power supplied during test and those periods when the solar array power is not available.	F/III,2.2.6/-	○	○	○	○	○

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
4.1.3.17	Power Output		O	O	O	O	O
	Orbital average - min. 500 W, max TBD	F/III,2.2.1.2/-					
	Peak power - 5.6 KW for 10 min. day or night						
4.1.3.18	Impedance (at power module/structure interface connector)	F/III,2.2.1.3/-	O	O	O	O	O
	Not to exceed 0.15 ohms - 1 Hz to 5 Hz 0.5 ohms - 5 KHz to 100 KHz 1.0 ohms -100 KHz to 1 MHz						
4.1.3.19	Batteries		O	O	O	O	O
	Type TBD						
	Capacity - Total TBD - Minimum 40 amp hrs - Maximum 120 amp hrs	F/III,2.2.2.2/-	O	O			
	Depth of discharge Not to exceed 50% for normal orbital operations	F/III,2.2.2.3/-	O	O	O	O	O
4.1.3.20	The solar array shall be configured (retractable/jettisonable) to permit EOS retrieval for refurbishment.	FA 2.36	O	O	O	O	O

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.1.4	Attitude and Control						
4.1.4.1	Provide for spacecraft control during initial acquisition, reacquisition, normal operations, orbit adjustment maneuvers, and coarse attitude hold mode.	F/I, 2.1/-	●	●	●	●	●
4.1.4.2	Where an integral Tug is required, the ACS shall provide attitude and rate signals required for its control	F/I, 2.1/-			●		
4.1.4.3	The ACS shall be driven directly in response to error signals generated by sensors or via the on-board computer	F/I, 2.1/-	●	●	●	●	●
4.1.4.4	The ACS shall be capable of operating within specification cyclic disturbance torque limits of:	F/I,2.2.5/-					
	(see torque table below) 300 - 900		●	●	●	●	●
	Geosynch						●
4.1.4.5	The ACS shall accommodate the following range of spacecraft mass properties: Weight 2500 - 25,000 lb; Moment of inertia 500 - 100,000 slug - ft^2	F/I,2.1/-	○	○	○	○	○
4.1.4.6	ACS response cut-off frequency shall be 0.1 Hz	F/I,2.1/-	○	○	○	○	○
4.1.4.7	In Acquisition Mode: a. Reduce S/C rates to less than ± 0.03 deg/sec; b. Define S/C inertial attitude to within ± 2 deg	F/I,2.2.1/- (TS 6)	○	○	○	○	○

Torque table for 4.1.4.4:

Orbit Alt (n.mi)	Torque (ft-lb) Average (Secular)	Cyclic (Peak)
300 - 900	10^{-5} to 0.1	2×10^{-4} to 0.2
Geosynch	10^{-6} to 0.01	2×10^{-5} to 0.02

Mass properties for 4.1.4.5:

Weight	2500 - 25,000 lb
Moment of inertia	500 - 100,000 slug - ft^2

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
4.1.4	Attitude and Control (Cont'd)						
4.1.4.8	In Inertial Attitude Hold Mode, maintain an arbitrarily selected inertially referenced attitude to: a. Before in-orbit calibration, ± 0.03 deg/hr b. After in-orbit calibration, ± 0.003 deg/hr	F/I,2.2.2/-	C	C	C	C	
4.1.4.9	In Coarse Attitude Hold Mode: a. Provide a high level of reliability b. Maintain the sun line normal to the solar array within ± 7.0 deg (total) c. Limit S/C rates to < 0.05 deg/sec/axis d. Maintain this mode of operation for up to 30 days	F/I,2.2.3/-	C	C	C	C	C
4.1.4.10	In Slew Mode: a. Reorient the S/C (on a single axis basis) up to 90 deg with an accumulated error of < ± 0.03 deg b. Provide a slew rate ≥ 2 deg/min	F/I,2.2.4/-	C	C	C	C	C
4.1.4.11	For normal operations, the ACS shall meet the following performance levels per axis: a. Pointing accuracy < ± 0.01 deg b. Pointing stability (1) Average rate deviation < ± 10^{-6} deg/sec (2) Attitude jitter (a) Up to 30 sec period, ≤ ± 0.0003 deg (b) Up to 20 min period, ≤ ± 0.0006 deg c. Maintain these conditions for periods up to 1 hour	F/I,2.2.5-1/- F/I,2.2.5-2/- (TS 6)	C	C	C	C	C

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5	A	B	C	D	E	F	
4.1.4	Attitude and Control (Cont'd)													
4.1.4.12	The ACS shall provide the capability for utilizing error signals generated by a stellar payload instrument for S/C control. It shall meet the following performance levels (peraxis) exclusive of instrument error signal limitations: a. Pointing accuracy $< \pm 3 \times 10^{-6}$ deg b. Attitude jitter $< \pm 10^{-7}$ deg	F/I,2.2.5.2/-	O	O	O	O	O							
4.1.4.13	Maintain spacecraft attitude to $\leq \pm 0.25$ deg in all axes	O/ - / - C/ - / 6	O								O			
4.1.4.14	For initial SMM, provide pointing accuracies of: a. Pitch 1 to 5 $\widehat{sec}$ (rms) b. Yaw 1 to 5 $\widehat{sec}$ (rms) c. Roll 6 $\widehat{min}$ (rms)	M/3.3.3.5/18												O
4.1.4.15	For Shuttle launched SMM, provide pointing accuracies of: a. Pitch 2 $\widehat{sec}$ b. Yaw 2 $\widehat{sec}$ c. Roll <u>TBD</u>	Q/ - / -												O
4.1.4.16	For initial SMM, provide pointing stability of: a. In each of two axes, 1 $\widehat{sec}$ for not less than 5 min b. In the third axis (normal to line-of-sight to sun), 0.1 deg	M/3.3.3.5/18 M/4.5.1/63												O
4.1.4.17	For Shuttle launched SMM, provide pointing stability of: a. In each of two axes, 0.22 $\widehat{sec}$ for not less than 5 min b. In the third axis, <u>TBD</u>	Q/ - / -												O

	REQUIREMENT	SOURCE	1	2	3	4	5	A	B	C	D	E	F	
4.1.4	Attitude and Control (Cont'd)													
4.1.4.18	Provide pointing to any selected point on the solar disc (± 15 min pointing range in each of two axes)	M/4.5.1/63												O
4.1.4.19	Provide the capability to slew 5 min within 1 sec time	M/3.3.3.5/18												O
4.1.4.20	Provide the capability to acquire the required attitude position from any orientation	M/3.3.3.5/18												O
4.1.4.21	Provide the capability of pointing sensor to ± 1 Km accuracy at subpoint (28 μ rad).	N/ - / -											O	
4.1.4.22	Provide the capability of holding pointing to ± 25 meters (0.7 μ rad)	N/ - / -											O	
4.1.4.23	Provide two classes of slew rate: a. Incremental traverses at selectable rates of 100 to 800 km/min b. Sustained traverse across CONUS (5000 km) in 5 min (≈ 0.028 rad/min).	N/ - / -											O	
4.1.4.24	Provide means of activating attitude control price to S/C separation from L/V	FA-2.16.5.23	O	O	O	O								

7

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	B	C	D	E	F
4.1.5 Structure												
4.1.5.1 Mechanical configurations of subsystem modules shall be standardized.	E/2.1/2-1 (TS 14)	●	●	●	●	●						
4.1.5.2 The only structural contact that the EOS has with the launch vehicle is at the transition ring.	E/2.4.1/2-3											
4.1.5.3 The systems contractor shall provide a NASTRAN computer model (desk) of the module structure to S/C subsystem contractors.	F/IV,1.1.1/-	○	○	○	○	○						
4.1.5.4 Only one S/C subsystem module configuration shall be provided which shall satisfy the specific requirements of the 3 basic S/C subsystems (C & DH, Att. Control & Power).	F/IV,1.2/-	●	●	●	●	●						
4.1.5.5 The S/C subsystem module shall have a total volume of not less than 23 cu. ft. (approx. 48" x 48" x 18").	F/IV,1.3.1/-	○	○	○	○	○						
4.1.5.6 The max. wt. of S/S module shall be 100 lb.	F/IV,1.3.2/-	○	○	○	○	○						
4.1.5.7 The max. load carrying capability of S/S modules is 600 lb.	F/IV,1.3.2/-	○	○	○	○	○						
4.1.5.8 The S/S module structure shall be designed for max steady-state-acceleration of 25 g's longitudinal & 15 g's for lateral.	F/IV,1.3.5.1/-	○	○	○	○	○						
4.1.5.9 Fittings for the purpose of mounting the S/S modules to the S/C shall be compatible with the module resupply concept. The maximum repeatable mechanical misalignment of a module to S/C structure shall be $\pm$ 15 arc seconds in each axis.	F/IV,1.3.6.1/-	○	○	○	○	○						
4.1.5.10 Accommodate 600 ft^3 (17 m^3) of SEASAT experiments	O/ - / -	○								○		
4.1.5.11 Accommodate 500 lb of SEASAT experiments	O/ - / -	○								○		
4.1.5.12 Provide appropriate structure to accommodate interfacing with the Delta launch vehicle.	M/3.3.3-1/14	○	○									

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	B	C	D	E	F	
4.1.5.13	Support a minimum SMM scientific payload weight of 1431 lb (649 Kg)	Q/ - / -												O
4.1.5.14	Provide a minimum clear viewing area of 7 ft^2	M/3.3.3.1/15												O
4.1.5.15	Accommodate a minimum total SMM instrument volume of 13.5 ft^3 (0.38m^3)	Q/- / -												O
4.1.5.16														
4.1.5.17	Accommodate a SEOS instrument volume of 459 ft^3 (13 m^3)	N/- / -	O								O			
4.1.5.18	Support a minimum SEOS scientific payload weight of 2646 lb (1200 Kg).	N/- / -	O								O			

Revision

Date

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	
4.1.6 Thermal							
4.1.6.1 Each S/C module will be independently thermally controlled	D/III/25 E/2.1.2/2-4	O	O	O	O	O	
4.1.6.2 Internal components heat sink will operate at 70° $\pm$ 20°F	D/II/8	O	O	O	O	O	
4.1.6.3 Maximize thermal isolation of subsystem modules from instrument modules by insulation with an effective emissivity of ≤ 0.05	E/2.1.2/2-4 F/IV,1.3.6.3/-	O	O	O	O	O	
4.1.6.4 Maintain SMM experiment temperatures at 15°C $\pm$ 10°	M/3.3.2/15						O

Revision Date

REQUIREMENT		SOURCE	OPTION 1	2	3	4	5
4.1.7	~~Pneumatics~~						
4.1.7.1	Provide thrusters, propellant storage and controls to effect attitude control	G/3.2.2.2.2/3-33	O	O	O		
4.1.7.2	Provide impulse requirements as follows:	AF/Table 4,6,7/-	O				

Option 1

Maneuver	Impulse - lb-sec R	P	Y
Initial stabilization	6	11	11
Control-orbit correction	0.5	17	17
Stabilization after array deployment	0.5	1	1
Gravity Gradient compensation	35	79	0
Contingency 10%	4	11	3
Total	46	119	32

Option 2 (Option column: O under 2)

Maneuver	Impulse-lb-sec R	P	Y
Initial stabilization	7	14	14
Control-orbit correction	0.5	21	21
Stabilization after array deployment	1	2	2
Gravity gradient compensation	105	236	0
Contingency 10%	11	27	4
Total	125	300	41

REQUIREMENT	SOURCE	OPTION 1 2 3 4 5
4.1.7.2 Provide impulse requirements as follows (continued)		O (3)

Option 3

Maneuver	Impulse - lb-sec		
	R	P	Y
Initial stabilization	7	15	15
Control during SRM burn	5	210	210
Stabilization after SRM jettison	2	3	3
Control-orbit correction	1	29	29
Stabilization after array deployment	1	2	2
Gravity gradient compensation	105	238	0
Contingency 10%	2	50	26
Total	123	547	285

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	B	C	D	E	F	G
4.1.8 Instrument Data Handling	AM/-/-	●	●	●			●	●	●				

Provide a Data Handling Subsystem which accepts data from instruments whose outputs are formatted into two identical rate digital streams for transmission to the ground. These instruments are called the Thematic Mapper (TM) and High Resolution Pointable Imager (HRPI). Two additional lower rate digital data streams one for each of the instruments, are also required. The data rate is about one quarter that of the high rate (wideband) data and is referred to as compacted data.

The Data Handling Subsystem has two primary functions, wideband data combining and selective or compacted data combining. In wideband the input data lines (seven for the TM and four for the HRPI) are multiplexed together, framed and combined with a small amount of overhead. These two data streams at 85.7 Mbps (one for HRPI and one for TM) are inputs to a spacecraft QPSK modulator.

Data compaction reduces the wideband data rate to a value that can be handled by a relatively low cost ground station. The data rate selected is exactly one quarter of the wideband rate, or approximately 21.4 Mbps. Data here includes actual data from the instrument plus required overhead and framing.

Three interfaces are defined, as shown in fig4.1.8-1 between ~~the~~ instrument data handling units and instruments, on-board processor and modulators. Data and framing information are supplied via the interface with the instruments. Overhead information required to process the data on the ground and to select the compaction algorithm is received from the spacecraft on-board processor. The third interface is the wideband and compacted data stream to the modulators.

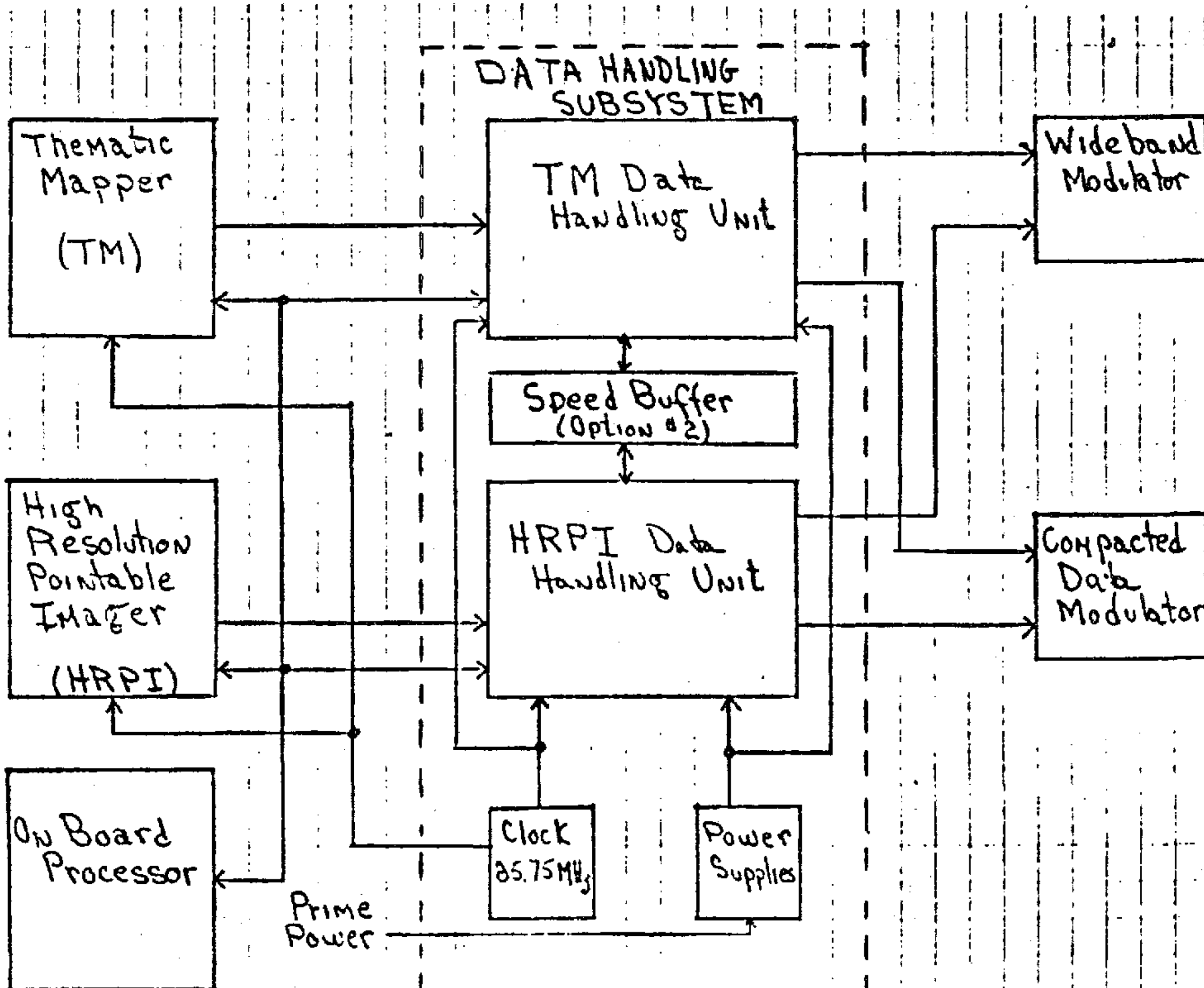


Fig.4.1.8-1 Data Handling Subsystem Interface

REQUIREMENT	SOURCE	OPTION
		1 2 3 4 5
4.2.1 Data Acquistion and Communications		
4.2.1.1 Orbit definition shall be sufficiently accurate to permit orbit predictions 2 weeks in advance.	M/5.1.1/71	O
4.2.1.2 Orbit predictions shall be sufficient to predict:	M/5.1.1/71	O
a. S/C position within 10 km for S-band acquisition with 30 ft diameter antennas (1° beamwidth)		
b. Times of S/C entrance and exit into and from eclipse (spherical, no atmosphere earth and point-source sun) with an accuracy of $\pm$ 8 sec in time.		
c. S/C position within 500 meters 24 hours in advance.		
4.2.1.3 Relay real-time command data from the Operations Control Center (OCC) to the spacecraft at 800-1200 bps.	M/5.1.2/71	O
4.2.1.4 Command data transmission shall have a bit error rate (BER) $\leq 10^{-6}$	M/5.1.2/71	O
4.2.1.5 Provide for at least one command opportunity of not less than 5 minutes on each orbit	M/5.1.2/71	O
4.2.1.6 Provide for receipt of a S/C command memory dump and relay to the OCC within three minutes of the start of the dump	M/5.1.2/71	O
4.2.1.7 Provide the capability for receipt of real-time S/C telemetry data at 6.4 Kbps for a minimum of one contact/orbit with a minimum contact time of six minutes and relay to the OCC in real-time.	M/5.1.3/71	O
4.2.1.8 Provide for receipt of S/C telemetry data at 128 Kbps for:	M/5.1.3/72	O
a. One contact per orbit with a duration of 6 minutes		
Or		
b. One contact per two orbits with a duration of 11 minutes		

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.2.1.9 Provide for the relay of S/C telemetry data to the OCC as follows: a. Five minutes of 128 Kbps data within 30 minutes of receipt Or b. Ten minutes of 128 Kbps data within 60 minutes of receipt	M/5.1.3/72					
4.2.1.10 Telemetry acquisition and command opportunity periods must be completely overlapping	M/5.1.3/72					
4.2.1.11 The telemetry RF link shall provide a BER $\leq 10^{-5}$	M/5.1.3/72					
4.2.1.12 Tracking, telemetry, and command support shall be provided for a minimum period of launch to launch plus one year. Support is desired from launch to launch plus two years.	M/5.1.3/72					

Revision

Date

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.2.3	Data Processing						
4.2.3.1	All products, standard and custom, will be radiometrically corrected	A/2.1.2/2-3	O	O	O	O	O
4.2.3.2	The standard products requirements are:	A/2.1.2/2-3	O	O	O	O	O

	Geometrically Uncorrected	Geometrically Corrected	Reduced Data Options
B/W Film	X		
Color Film	X		
High Density Digital Tape (HDDT)	X	X	
Computer Compatible Tape (CCT)		X	X

	REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.2.3.3	Custom output products from the system shall include film products geometrically corrected with custom gamma capability and sub-area enlargement capability to specific map scales	A/2.1.2/2-3	O	O	O	O	O
4.2.3.4	Custom film products are those of specific false color mix	A/2.1.2/2-3	O	O	O	O	O
4.2.3.5	Custom digital products (CCT output) include sub-area or swath width reduction, band sequential or band interleaved, specific bands, and reduced resolution	A/2.1.2/2-3	O	O	O	O	O
4.2.3.6	Quality requirements for the output products are shown in Table 4.2.3-1	A/2.1.2/2-3	O	O	O	O	O
4.2.3.7	Processing of the daily volume of data shall be accomplished within a 16 hour day	A/2.1.2/2-5	O	O	O	O	O
4.2.3.8	Basic processing of image data (i.e., geometric correcting, radiometric calibration, etc.) shall be performed digitally	A/2.1.3/2-5	O	O	O	O	O
4.2.3.9	Data products and ranges are in Table 4.2.3-2	A/2.1.3/2-5	O	O	O	O	O

	GEOMETRICALLY UNCORRECTED*		GEOMETRICALLY CORRECTED+	
	TM	HRPI	TM	HRPI
Swath Width	185km	48km	185km	48km
Spatial Resolution				
Visible	30m	10m	30m	10m
Thermal	120m	--	120m	--
Linearity (μrad)	0.2 IFOV	0.2 IFOV	0.2 IFOV	0.2 IFOV
Band to Band Registration	0.1 IFOV	0.3 IFOV	0.1 IFOV	0.3 IFOV
Position Accuracy(w/o GCP)**	±450m	±450m	±170m	±170m
Position Accuracy(with GCP)**	--	--	± 15m	± 15m
Relative Radiometric Accuracy				
Visible				
Tape	± 1.6%	± 1.6%	± 1.6%	± 1.6%
Film	± 5%	± 5%	± 5%	± 5%
Thermal				
Tape	± 1K	--	± 1K	--
Film	± 3K	--	± 3K	--

*Includes radiometric correction, earth-rotation correction, line-length adjustment, correction for earth curvature, and predicted emphemeris.

+Additionally includes use of best-fit ephemeris from measured data.

**GCP = ground control points.

SYSTEM OUTPUT QUALITY REQUIREMENT

TABLE 4.2.3-1

PRODUCT	DATA VOLUME	NUMBER OF DATA USERS	NUMBER OF FORMATS
HDDT (uncorrected)	10^{10}-10^{12}bits/day	2 - 10	--
HDDT (corrected)	10^{10}-10^{12}bits/day	2 - 10	---
CCT (corrected)	10^{9}-10^{10}bits/day	10 -100	1 - 5
BLACK&WHITE POS/NEG (1)	20 - 200 scenes/ day	5 - 50	1 - 3 (3)
BLACK&WHITE PRINTS		5 - 10	1 - 3 (3)
COLOR POS/NEG (2)	10 - 100 scenes/ day	2 - 20	1 - 3 (3)
COLOR PRINTS		2 - 10	1 - 3 (3)

(1) FIRST GENERATION PRODUCT - 241MM (9.5 inch)

(2) SECOND GENERATION PRODUCT - 241MM (9.5 inch)

(3) ENLARGEMENT TO STANDARD MAP SCALES

DATA PRODUCTS AND RANGES

TABLE 4.2.3-2

REQUIREMENT		SOURCE	OPTION
			1 2 3 4 5
4.2.3	Data Processing (Cont'd)		
4.2.3.10	Provide processing of experiment data a. 6.4 Kbps telemtry data rate b. 6.0×10^8 bits/day c. 100% orbital coverage	M/7.1.c/85	O
4.2.3.11	Accept investigator's data base on formatted magnetic tapes	M/7.1.d/85	O
4.2.3.12	Provide quick-look data processing to 10 principal investigators on a daily basis	M/7.1.e/85	O

REQUIREMENT	SOURCE	OPTION
		1 2 3 4 5 A BC DE FG

4.2.3.13 Input Data Load

AH/-/-

The input to the CDPF consists of digital data as recorded by high speed instrumentation tape recorders. The range of input data to be considered by each of the hardware configurations is:

System / Instr.	Minimum	Baseline	Expanded
TM	20 scenes*/day 3.3×10^{10} bits/day	90 scenes/day 1.5×10^{11} bits/day	
TM and HRPI**	20 scenes/day 3.3×10^{10} bits/day	90 scenes/day 1.5×10^{11} bits/day	400 scenes/day 6.7×10^{11} bits/day

*TM scene: 6168 x 6165 7-bit pixels x $6\frac{1}{4}$ bands = 1.664×10^{9} bits/scene.

*HRPI scene: 3200 x 12333 7-bit pixels x 4 bands = 1.105×10^{9} bits/scene.

**To a first-order approximation the processing requirements for the TM and HRPI are similar.

4.2.3.14 Quantity of Data Processed and Archived

AH/-/-

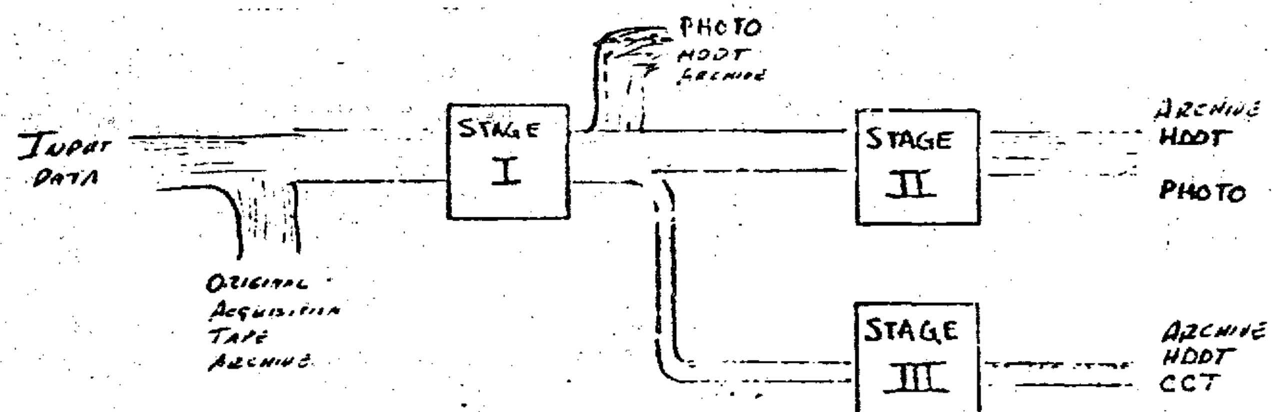
The percentage of the total data input from the above table which are to be processed and archived at each stage is:

Processing Stage	% Data Processed	% Archived	Internal Purge (Months)
Raw Input Data	0	100	∞
I	100	100	3,6,12
II	50,100	50,100	3,6,12
III	20,50,100	50,100	3,6,12

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	B	C	D	E	F	G
The Stage II and Stage III processing are not necessarily mutually exclusive. The Stage II and Stage III processing loads should be considered additive as long as their sum does not exceed 100 percent; above this point Stage III processing replaces Stage II processing. Thus when Stage III processing is 50 percent only the Stage II processing option of 50 percent should be considered.													

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	BC	DE	FG
4.2.3.15 **Output Products**	AH/-/-	O	O				O	O		

The following figure shows the requirement for output (user) products at 3 points:



Throughput Model.

The HDDT (High Density Digital Tape) refers to any very high density tape (> 10,000 bpi) not directly readable (without special interface hardware) by a computer. The CCT (Computer Compatible Tape) refers to other magnetic tapes with density < 10,000 bpi that are directly readable by computers. The photo products consist of B&W film (positive and negative), B&W prints, color film (positive and negative) and color prints. The B&W and color film are to be 241mm (9.5 inch). The B&W film is to be a first generation product; i.e., produced directly from the digital data through, for example, a laser beam recorder. The color film is to be a second generation product; i.e., produced from B&W film.

REQUIREMENT	SOURCE	OPTION
		1 | 23 | 4 | 5 A | BC | DE | FG

Not shown in the Figure are custom products. Custom photo products include special gamma correction, special sub-area enlargement to specific map scales and special false color mix. Custom digital products relate only to CCT and include partial scenes (sub-area or swath width reduction), special format and reduced resolution. Initially, as a first order approximation, assume these custom products to require the same processing required by other products identified in the Figure.

Table - shows the range of data products to be considered.

Product	Number (Each Different)	Av. Copies of Each **	No. Users Receiving	Number Formats***
HDDT*	2, 20, 200	1	2-20	1
CCT (6250 bpi)	2, 10	5	10-50	5
CCT (1600 bpi)	1, 10	10	20-100	5
B&W Film	20, 200	1	5-50	3
Color Film	10, 100	1	2-20	3
Prints (B&W and Color)	Existing ERTS Photolab		2-20	3

*Distributed among Stages I, II and III. Assume a mix of packing densities to equal total specified. The number of HDDTs specified is based on packing roughly 10^{10} bits per HDDT.

**Does not include archive requirements.

***Formats for tape are discussed separately. Formats for photo included full scenes at $1:10^6$ scale and multiple scenes at increased scale.

Table - User Data Products.

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5	A	BC	DE	FG
4.2.3.16 **Throughput Delay** Each CDPF hardware configuration should be sized to handle the required data load in a standard 16-hour day. This implies a 24-hour turnaround for most standing orders. Also assume up to 10 percent demand for retrospective orders for data previously archived, included as part of the load defined in ~~(Table)~~ para. 4.2.3.14	AH/-/-	O	O				O	O		

REQUIREMENT		SOURCE	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5
4.2.4	Data User Services						
4.2.4.1	Low Cost Ground System (LCGS)	(TS 9)					
4.2.4.1.1	The LCGS will accept direct readout of selected TM or HRPI data	A/2.1.5/2-6	O	O	O		
4.2.4.1.2	Basic capabilities of LCGS are to display image data and produce photo products	A/2.1.5/2-6	O	O	O		
4.2.4.1.3	Additional capabilities, electable at user option, are data formatting and editing, computer aided analysis	A/2.1.5/2-6	O	O	O		
4.2.4.1.4	As a means of limiting quantities of data transmitted to LCGS, EOS on-board editing may be considered in the form of limited area coverage, restricted number of channels, or lower spatial resolution.	A/2.1.5/2-6	O	O	O		

REQUIREMENT	SOURCE	OPTION 1	2	3	4	5
4.4.4 Transportation & Handling						
4.4.4.1 A shipping container shall be provided to transport the S/C horizontally to the launch site	GAC	O	O	O	O	O
4.4.4.2 Shipping containers shall be provided for each of the three S/C assemblies: Instrument, S/S Modules, & Orbit Adjust/ Transfer Assembly, since spares will be shipped independently to the launch site	V / - / 1	O	O	O	O	O
4.4.4.3 Provide for a constant positive nitrogen purge within the instrument housing for contamination control during transportation.	W / - / 3	O	O	O	O	O

Revision 2 Date 6/14/74